Sky and TELESCOPE

Observing Mercury's transit

★

Vol. XXI, No. 1

JANUARY, 1961

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Sky and TELESCOPE

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Orbit of Venus

AT the Nautical Almanac Office of the U. S. Naval Observatory in Washington, D. C., a major long-term program has been determination of more precise orbits for the principal planets. R. L. Duncombe has now published an exhaustive study of the motion of Venus from 1750 to 1949, the first major revision of Simon Newcomb's work of about 70 years ago, which is still used in the national ephemerides for predicted positions of Venus.

Dr. Duncombe's orbit calculations are based upon approximately 24,000 meridian observations of Venus, twice the number that were available to Newcomb. Those since 1890 were made at seven observatories. His first task was to convert all these positions, secured with many different instruments, to a uniform system. Since the relative positions of the earth and Venus are nearly the same after a lapse of eight years, he divided all the observations into eight-year groups, and made a separate determination of the orbit for each interval.

While corrections to the old orbit are small, the elements of Venus are now much more precisely known. One historic discrepancy has been cleared up by Dr. Duncombe's establishment that the observed change in the node of Venus is actually in close agreement with theoretical prediction. In addition, the relativistic shift in the perihelion point of the orbit was found to be 8.06 seconds of arc per century, very close to the amount predicted by Einstein's equation.

Dr. Duncombe was able to determine an improved value of the mass of Mercury from its perturbations of the motion of Venus. His result for the mass is 1/5,970,000 that of the sun, with a probable error of about ±8 per cent.

The numerous timings of the transits of Venus across the sun in 1761, 1769, 1874, and 1882 were assigned heavy weight when used by Newcomb in his orbit determination. Dr. Duncombe, however, employed only meridian observations. The contact times at the four transits are vitiated by small systematic errors, and no longer should be used in orbit work.

The enormous amount of calculation done in this investigation is indicated by the fact that 200 pages of tables are devoted to intermediate results alone in the final report, Vol. 16, Part 1 of the *Astronomical Papers* which are prepared by the Nautical Almanac Office. If modern punched-card computers had not been used, the Washington astronomer stated, many more years would have been needed to complete the work.

Now under way at the Nautical Almanac Office is a thorough new investigation of the orbit of Mars.

From opposite sides of the world come these very different tektites. At the left, shown natural size, is one from Paracala, Philippine Islands. At the right is a tektite, enlarged to twice its size, found by R. W. Wright at Magnolia, Texas. All pictures of individual tektites with this article are from the Smithsonian Institution, Washington, D. C.

Tektites and the Cyrillid Shower

JOHN A. O'KEEFE, *Goddard Space Flight Center, National Aeronautics and Space Administration*

THE LAUNCHING of more than 30 artificial earth satellites in the three years since October 4, 1957, has given new impetus to the study of the only known instance of a natural satellite, or rather a group of natural satellites, close to the earth. These were the Cyrillids, sometimes referred to as the Canadian fireball procession of February 9, 1913.

Many of that shower's phenomena are illuminated by the physical and engineering studies, especially of satellite reentry, that have been made in the last few years. The study of this shower also offers the possibility of explaining the origin of tektites, those strange and beautiful glassy objects found in many parts of the world.

The Cyrillids attracted the attention of astronomers when they passed over Toronto on that night in 1913. According to Prof. C. A. Chant of the University of Toronto: "At about 9:05 on the evening in question there suddenly appeared in the northwestern sky a fiery red body which quickly grew larger as it came nearer, and which was then seen to be followed by a long tail. . . . In the streaming of the tail behind, as well as in the color, both of the head and the tail, it resembled a rocket; but, unlike the rocket, the body showed no indication of dropping to the earth. On the contrary it moved forward on a perfectly horizontal path with peculiar, majestic, dignified deliberation; and continuing in its course, without the least apparent sinking towards the earth, it moved on to the south-west where it simply disappeared in the distance. . . .

"Before the astonishment aroused by this first meteor had subsided, other bodies were seen coming from the north-west, emerging from precisely the same place as the first one. Onward they moved at the same deliberate pace, in twos or threes or fours, with tails streaming behind, though not so long nor so bright as in the first case. They all traversed the same path and were headed for the same point in the south-eastern sky. . . .

"Several report that near the middle of the great procession was a fine large star without a tail, and that a similar body brought up the rear. . . .

"Just as the bodies were vanishing,

As they passed over Toronto and in front of Orion, the Cyrillids caught the practiced eye of an artist, Gustav Hahn, and his wife. Now 94 years old, he was then an amateur astronomer and friend of C. A. Chant. His painting is courtesy "Varsity Graduate," University of Toronto.

Miss Catherine MacVicar Duncan, Thamesville, Ontario, who drew this sketch, reported hundreds of sparks in group 1, dozens in 2, fewer in the others. Of object 5, she said, "One big body floated along by himself. . . ." The last groups she noted to be much fainter than the others. Her location at Thamesville was about 150 miles southwest of Toronto and slightly west of the Chant trace. Hence the Cyrillids appeared to move toward her right. The eyewitness sketches with this article are taken from the "Journal" of the Royal Astronomical Society of Canada.

or shortly afterwards, there was heard in many places a distinct rumbling sound, like distant thunder or like a carriage passing over rough roads or over a bridge. In some cases three such sounds, following at short intervals, were heard; while a number of people felt a shaking of the earth or of the house.

"The entire time occupied by the display cannot be determined accurately, but [was] perhaps 3.3 minutes."

The observations at Toronto were supplemented by others from as far westward in Canada as the vicinity of Regina, Saskatchewan. In the easterly direction, Chant obtained accounts of the same group of bodies from Bermuda. He noticed that the regions from which he had reports lay along an arc of a great circle, with observers to the east of the circle seeing the shower in the west, and those west of the circle seeing it in the east. On this basis, Chant put forward the idea that the objects were natural satellites of the earth.

In the following years, new data filled out the arc over which the Cyrillids were seen. First, W. F. Denning discovered some shipboard observations that extended the arc to twice its original length, into the South Atlantic off Cape Sao Roque, Brazil. Next, W. H. Pickering located three more shipboard sightings which filled the gap between New York and Bermuda.

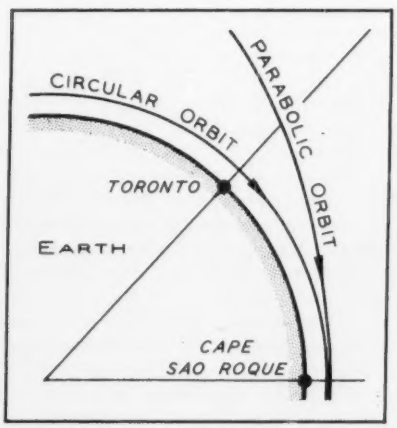
Finally, in the period from 1954 to the present, A. D. Mebane has located several dozen accounts in the files of newspapers in Minnesota, Wisconsin, Michigan, New York, Pennsylvania, and New Jersey. These last are especially welcome because they fill significant gaps in the picture given by Chant, and assure us that the phenomenon was actually continuous over its whole extent. In particular, they indicate that detonations of the kind heard in Toronto continued at least 200 miles to Towanda, Pennsylvania.

From the observations, it can be shown that the Cyrillids were moving about the earth in nearly circular orbits. To see this, imagine instead that they were moving in meteoric paths of low velocity with respect to the earth. Such orbits would be nearly parabolic in the vicinity of our planet. The diagram shows a cross section of the earth in the plane of the great circle along which the Cyrillids were seen and a supposed parabolic path. In this case, the orbital perigee would have been at Cape Sao Roque and the bodies would have been traveling parallel to the horizon, as observed there. At Toronto, on the other hand, meteors following such an orbit would fall at an angle of about 30 degrees with respect to the horizon. This flatly contradicts the observations, which, as Chant emphasized, point with remarkable unanimity to horizontal flight in this area.

Further, the fact that the individual meteors were seen for periods of a minute or so indicates that their flight was nearly horizontal. Meteors are generally invisible above heights of 100 kilometers and below 30 kilometers. If the Cyrillids had been traveling downward at an angle of 30 degrees to the horizontal, their visible paths would have been some 140 kilometers long. Their period of visibility would have been only 12 seconds, at the parabolic velocity of 11.2 kilometers per second, ignoring atmospheric deceleration.

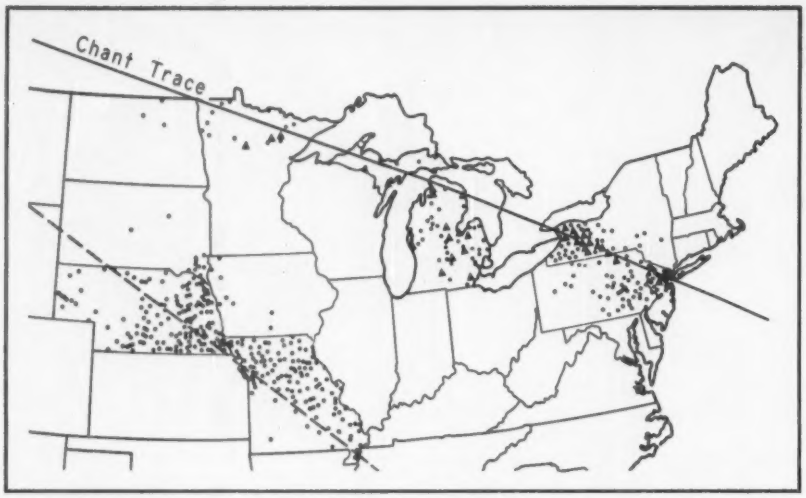
Obviously, the parabolic solution, with perigee near Cape Sao Roque, will not work. And if we move the perigee northwest along the path, then the meteors would have reached the earth's surface too soon and have been unobservable from Brazil. If we move the perigee farther to the southeast, the angle at Toronto gets even steeper. Increasing the velocity has the same effect, as the orbit becomes hyperbolic. If we lessen the velocity, however, the orbit becomes satellitic. This last is the only possible way to reconcile the orbit with the observations.

From the physical point of view, the narrowness of the belt along which the Cyrillids were seen is hard to understand unless they were following one another in similar orbits. If this was an ordinary meteor shower, the swarm causing it would have to be very thin — about 100 miles across — and some two or three thousand miles long. Furthermore, the swarm would just have happened to strike the earth so that its plane coincided



Sketched here, not to scale, are a parabolic and a circular orbit in the plane of Chant's great circle. Over Toronto, nearly 50 degrees from Cape Sao Roque, the parabolic arc descends noticeably. But the observers' reports of nearly level flight fit only the circular orbit, which is parallel to the earth's surface.

This is a moldavite, from Netolitz in southern Bohemia. The two-times enlargement shows its broken and pitted fused surface. Tektites are glassy, and characterized by low indexes of refraction, less than those typical of man-made glass.



To the author for this research, A. D. Mebane lent his entire collection of positive and negative replies to extensive inquiries along the Chant trace from Minnesota to New York City. Triangles show positive observing reports. In the Midwest region of a second possible fall, the round dots show the wholly negative results of a search conducted by the author and his correspondents.

with the center of the planet. Because of the improbability of such a shower structure, and our preceding arguments, we conclude that the objects of the meteor procession of February 9, 1913, were in fact satellites of the earth.

The name Cyrillid is chosen in view of the nature of the bodies as earth satellites. Having been in orbit around the earth, they could have no true radiant, and hence cannot be named, like the Leonids, after the constellation of the radiant. Being associated with no comet, so far as is known, they cannot be named, like the Bielids or the Giacobinids, after a comet. The Perseids, on the other hand, which appear about St. Lawrence's day (August 10th), were traditionally called the Tears of St. Lawrence. On this precedent is based the name Cyrillid, the 9th of February being St. Cyril's day.

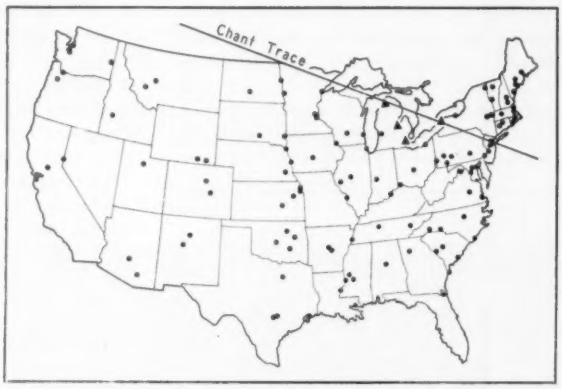
Two attempts have been made to find evidence of a second revolution of the Cyrillids. The map at the right is from examining about 200 United States metropolitan newspapers, principally dailies from about 120 cities — practically the entire collection of the Library of Congress. Two doubtful stories fall off the chart, but on the great circle established by Chant. They were reported in newspapers of February 15th in New York and Philadelphia from the crews of ships docking there. Both give incorrect dates for the shower, and one is obviously inaccurate. Whether these points are included or not, it is clear from the map that accounts of the shower are to be found only along the Chant trace.

Assuming that the Cyrillids were earth satellites, we might expect some of them to make more than one trip around. The next revolution, with a period of 91½ minutes, would have carried them over the Middle West, above the populated regions of Nebraska, Iowa, and Missouri. In the chart above, the results of a concentrated search along this projected path are compared with the work of Mebane along the Chant trace. Many of these newspapers were examined by me; the rest by reliable investigators recommended by state historical societies. I verified my ability to locate such items by checking newspapers along the Chant trace, even locating a few stories that had been overlooked by the editors with whom Mebane corresponded. But in the area of the expected second passing, none of us was able to locate a single article referring to the shower, with the trivial exception of some reprintings of a wire-service dispatch from Buffalo, New York.

These negative results, many from areas of clear weather on that night, lead to two important conclusions: They reemphasize the idea, first stated by Chant, that the Cyrillids were visible only on and near a great circle; and they make it very unlikely that any substantial part of the Cyrillid shower survived for another circuit of the earth.

The second conclusion gives us a significant clue to the origin of the Cyrillids. It means that they had been moving around the earth as a group of bodies for very few revolutions, perhaps only one before the passage over Toronto on which they were observed. Suppose they had been *individually* in orbit for many revolutions before they were seen. Because they would have different sizes and shapes, the drag by the earth's atmosphere would be different for each of them and would slow some more than others. Several mathematicians working on the orbit of Sputnik I discovered that orbital lifetime of a satellite is inversely proportional to the drag coefficient.

Since it is reasonable to suppose that the drag coefficients differed from one another by as much as a factor of two, some of the satellites would make twice as many revolutions as others. Thus, the entry of the cluster into the lower atmosphere would be spread over a number of revolutions equal to at least half the total number of circuits made by any part of the cluster. Numerical integrations have failed to show any way in which all the members of such a shower could disappear in one revolution.



Results of a search through newspapers published at the time of the 1913 meteor procession. Triangles locate observers who reported seeing the shower; dots indicate papers that carried no local reports.

Part of the display seen by Col. W. R. Winter from Bermuda. As they moved across the sky, two large bodies broke into smaller parts which developed tails of gas and sparks. The slowly traveling procession, which took approximately two minutes to pass a given point, contained some 100 fragments. The curvature of the tails, also mentioned in Col. Winter's written report, was believed by Chant to have been an illusion.

The most probable explanation, it appears, is that the Cyrillids were formed from a single body, which had made a considerable number of revolutions around the earth. Eventually, perhaps as a result of lunar perturbations, the perigee of the body came into the lower atmosphere. The orbit then contracted, in the manner which has become familiar to all of us from artificial satellites: the semi-major axis and eccentricity of the orbit decreased.

In each succeeding perigee passage, the atmospheric heating became greater, not only because the successive passes were slightly lower but, above all, because each revolution lasted longer than the previous one as the orbit's eccentricity diminished steadily.

Eventually, the heating became very great, and the body began to melt. Drops were swept from its surface. Some of these followed the main orbit out to apogee; others, formed earlier, were retarded more. In accordance with the now familiar paradox of drag retardation, these got *ahead* of the main body and preceded it on the next (final) pass. Together with more drops formed on the final pass, they constituted the bodies of the shower. The main mass was perhaps identical with the "fine large star without a tail" mentioned by Chant as ending the procession.

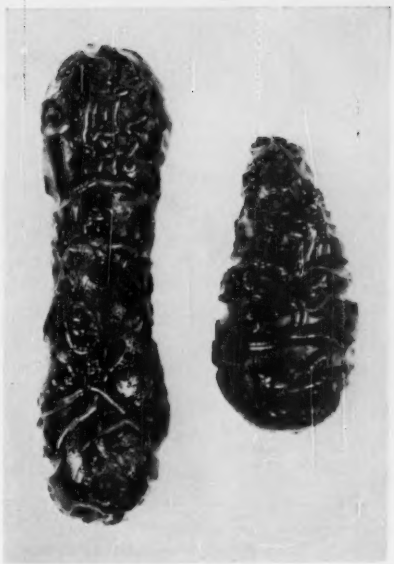
It is very unlikely that fracture played a significant role in the breakup, even if a pressure of 2,000 dynes per square centimeter acted on the body. This is a tenth the pressure a skier might exert on snow, and is not enough to fracture any ordinary solid substance. Over a distance of 1,000 kilometers, however, work amounting to 2×10^{11} ergs would be done, enough to melt a layer of stone two centimeters thick. Hence, melting is a much more probable mechanism for the breakup than is fracture.

Detailed calculations have been made on this basis, using the theory developed by E. Opik. One of the most striking results is that only bodies moving in grazing satellite orbits can yield drops the size of tektites. Such large drops (up to 15 centimeters in diameter) require a very delicate equilibrium. Their surface tension is not adequate to resist drag forces as powerful as those acting on a typical meteorite coming into the atmosphere.

The critical point is that at which the body has encountered a total mass of air equal to its own mass. For a rapidly descending object, this point is reached at a much lower level than for one moving nearly parallel to the earth's surface. At this lower level, the denser air produces a strong drag, tending to split large drops. Hence, the droplets formed from a typical meteorite are much smaller (of the order of half a millimeter or less) than those from a re-entering artificial satellite. Small meteorite droplets have actually been recovered by E. L. Krinov in the U. S. S. R. (SKY AND TELESCOPE, September, 1959, page 617). The larger drops have been observed (but not actually recovered) during the descent of Sputnik II, according to L. G. Jacchia.

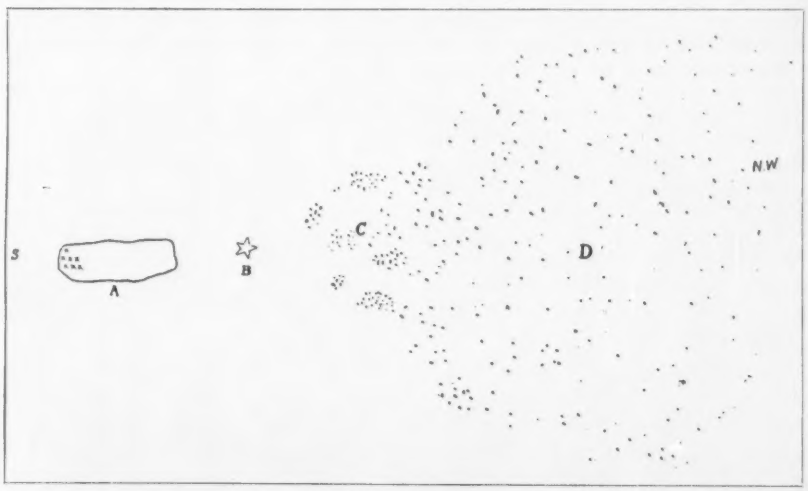
Opik's theory also permits us to make a rough calculation of the temperatures, rates of flow, thicknesses of the liquid layer, and other quantities, during the production of the drops. The values found appear to be reasonable, agreeing with the physical characteristics of the tektites themselves. Opik also provides for calculating the masses of the bodies from the integrated luminosities. Despite the rather fragmentary information on Cyrillid brightnesses, it appears that they had individual masses in the range of tektites.

From detailed studies of the chemistry of the latter, certain conclusions can be drawn. Their iron is all, or nearly all, in the reduced state (ferrous oxide). With solar furnaces working at the fusion temperatures of tektites, F. Senftle and his coworkers at the National Bureau of

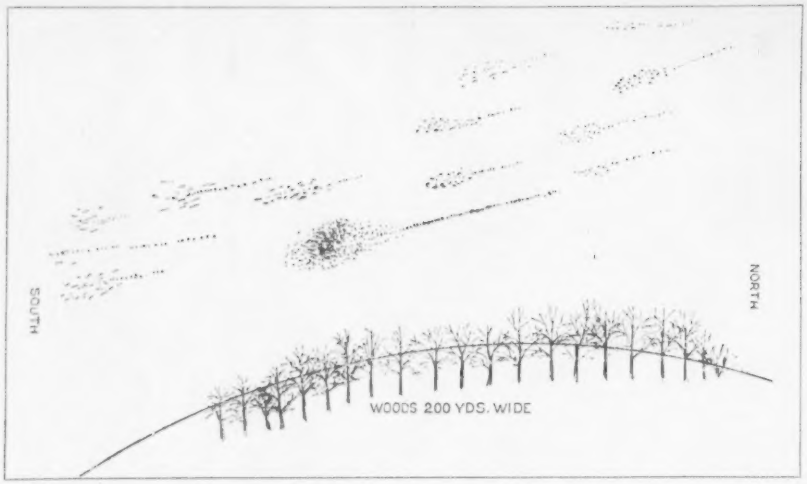


The dumbbell and drop forms of billitonites, found in the Malay Archipelago and named for the Island of Billiton, are shown actual size.

While snowshoeing in Parry Sound, Walter L. Haight was astonished to see groups of dull reddish meteors moving from the west in apparently level flight. He sketched two groups of four or five bodies followed by a few scattered ones, making a total of about 14. He was most impressed by the slow, measured pace of the flight, estimating its duration as 1½ to two minutes. Parry Sound is located about 120 miles north and slightly west of Toronto, quite far from the Chant trace.



From Fenlon Falls, 68 miles northeast of Toronto, Walter H. Stevenson counted seven bright, white "stars" in the first group, A in his diagram. They were closely followed by a reddish glow, like the glare from a fire. A bright white "star" at B, estimated to be nearly as brilliant as the planet Venus, preceded several reddish clusters marked C. A shower of red meteors, D, concluded the spectacle. The objects had "about the angular speed of a flying crow" and passed less than halfway up the western sky. The entire display lasted an estimated three minutes.



Seventy-four miles northeast of Toronto, at Centreton, John T. Ormiston compared the lengths of the meteor trails with the trees 200 yards in front of him. The woods subtended an angle of about 55 degrees, and by comparison the longest meteor was some 25 degrees.

Standards have found that only a few minutes are required to reduce ferrous oxide from ferric oxide. In the same way, they have shown that the almost complete lack of magnetism in tektites suggests a heating time of at least a few minutes. The lack of water points in the same direction.

On the other hand, V. Barnes has established that some fine filaments of nearly pure silica that appear in tektites tend to disappear after half an hour's heating. This ties down the heating time of tektites to roughly five to 15 minutes, which is also how long the Cyrillids were hot.

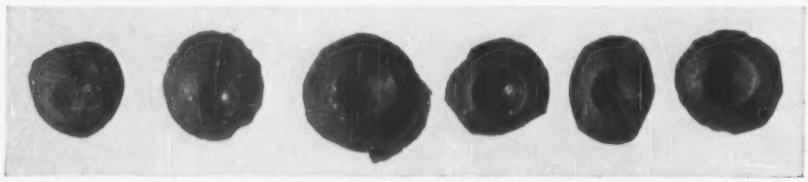
It is even possible to form an idea of the pressures that prevailed during tektite formation, for they contain bubbles in which the pressure is less than a thousandth of an atmosphere.

The association of tektites with showers of the Cyrillid type is thus supported by evidence from the size and form of tektites, their temperature of fusion, the duration of heating, and possibly the pressures involved. And the spotty distribution of known tektites over the earth's surface is consistent with falls of the Cyrillid type and not with those of the showers produced by ordinary meteor swarms.

By contrast, theories of the origin of tektites from terrestrial material, say by meteoritic impact, have serious trouble on most of these points. It is hard to see how an impact could yield velocities sufficient to propel tektites for thousands of miles, but not enough to distribute them over the whole earth; and we fail to find definite centers from which the concentration decreases in all directions outward.

It is hard to understand the lack of water and magnetism in terrestrial matter, or the conversion of ferric to ferrous iron within the very brief time available for heating the surface material. But most difficult of all is explaining the formation of large drops in the relatively steep descent of a meteorite, if tektites are thought to be meteoritic in nature. It is also difficult to account for the thorough melting of a substantial chunk of glass in the brief time of fall.

On the whole, I feel that the evidence strongly supports the idea that tektites form in showers such as the Cyrillids, and the ultimate origin of the body that initiated this shower is of great interest. Perhaps it could even have been a chunk thrown from the moon by meteoritic impact. The idea of a lunar tektite origin was suggested in this magazine by H. H. Nininger 18 years ago (February, 1943, page 12).



In many parts of the world, brown, green, and black tektites have been found, being named for the locations where they were originally picked up. These drops were found in Australia, where there are estimated to be several million. They are called australites, and have a common tektite shape, that of a button or a lens with a flange. Similar numbers of tektites lie elsewhere, but their distribution is spotty.

QUESTIONS... FROM THE S+T MAILBAG

Q. Where in the sky is Hubble's variable nebula?

A. In Monoceros, at right ascension $6^h\ 36^m.4$, declination $+8°\ 46'$ (1950 coordinates). Also known as NGC 2261, this fan-shaped nebulosity has the variable star R Monocerotis at its tip. For a Palomar photograph, see SKY AND TELESCOPE for January, 1954, page 79.

Q. I am an amateur astronomer studying French. Is there some popular astronomy magazine in that language you would suggest for reading?

A. *L'Astronomie* is a well-illustrated periodical, with articles by both professional and amateur astronomers. It is published by the Société Astronomique de France, 28 Rue Serpente, Paris 6, France. For nonmembers, a year's subscription (10 issues) costs 33 NF.

Q. What basic set of eyepieces is suggested for a 6-inch, f/8 reflector on an altazimuth mount?

A. A $1\frac{1}{4}$-inch ocular is useful for star fields, clusters, and nebulae; a 1-inch or $\frac{3}{4}$-inch for general views of the moon and planets; and a $\frac{1}{2}$-inch for lunar and planetary observing under good seeing conditions. With reflecting telescopes, Kellner and orthoscopic eyepieces are generally recommended.

Q. What is meant by star names such as 6 G. Sagittarii or 34 G. Piscium?

A. *G.* indicates that a star number is the one assigned in B. A. Gould's *Uranometria Argentina* (1879). This work consists of a catalogue and charts of southern stars to magnitude 7. In each constellation, the stars are numbered in order of right ascension.

Q. How are daily sunspot numbers determined?

A. By adding the number of visible spots to 10 times the number of spot groups. This total is multiplied by a constant, for most observers not far from unity, to bring the daily number into average agreement with a standard series, such as the Zurich sunspot numbers. Much care and observing experience are required to obtain consistent results.

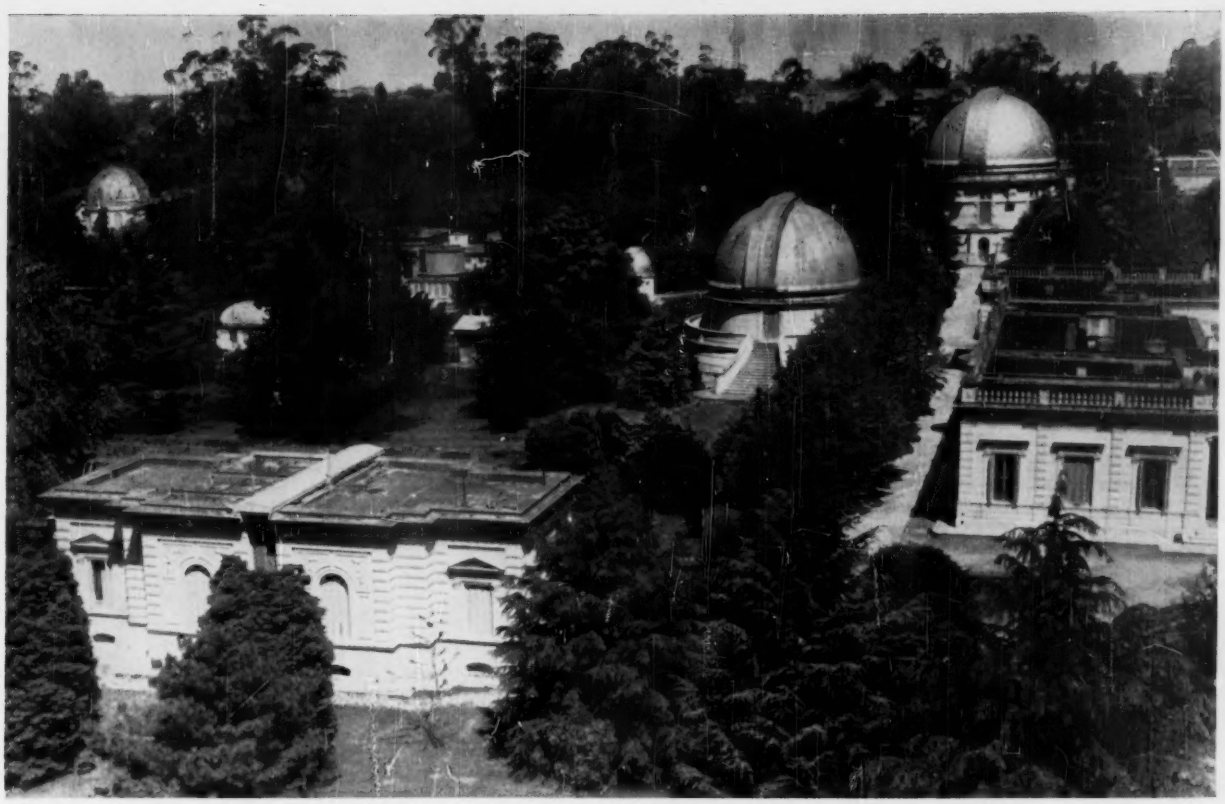
Q. What is an H-R (Hertzsprung-Russell) diagram?

A. It is a graph in which the vertical scale represents stars' absolute magnitudes, the horizontal scale spectral classes. Intrinsically bright stars are near the top of the diagram, faint ones below; hot, blue stars are toward the left, cool, red ones to the right.

Q. How fast does an asteroid appear to move with respect to the star background?

A. At opposition, the westward motion of a typical asteroid is about 10 to 12 minutes of arc per day.

W. E. S.



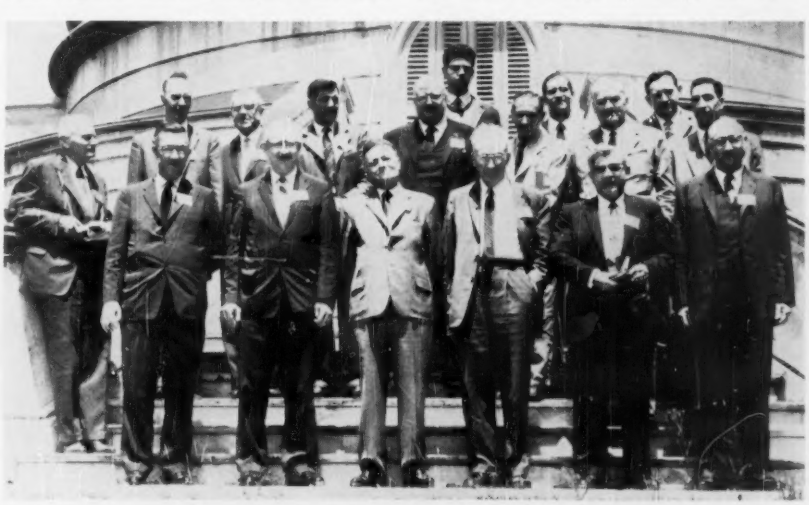
La Plata Observatory, founded in 1882, has long been active in Southern Hemisphere astronomy, and has been the source of numerous star catalogues. In the left foreground is the building of the 7½-inch Repsold meridian circle. Just right of center is the dome for the 31½-inch reflector, and behind and farther right, that of the 17-inch refractor. The main building extends out of the picture to the right. La Plata Observatory photograph.

CONFERENCES AT LA PLATA

ASTROMETRY and stellar evolution were the subjects of international meetings held November 7-12, 1960, at La Plata Observatory in Argentina, on the occasion of the 150th anniversary of that country's independence. After a joint opening session, in which director Reynaldo P. Cesco described the observatory's past accomplishments and future plans, the attending scientists participated in two separate programs.

The astrometry and celestial mechanics conference featured papers on meridian astronomy by S. Slaucitajs of La Plata, G. M. Clemence and F. P. Scott of the U. S. Naval Observatory, R. H. Stoy, Cape Observatory in South Africa, and M. S. Zverev of the Pulkovo Observatory. H. M. Jeffers, Lick Observatory, spoke on double stars, while J. Schilt of Columbia University discussed galactic dynamics. Dr. Cesco and Dirk Brouwer, Yale University, gave papers on problems of celestial mechanics.

A highlight of the astrometric program was a three-day excursion to the new Felix Aguilar station of La Plata Observatory. It is located at La Leona in Santa Cruz province, deep in Patagonia about 1,300 miles southwest of Buenos Aires (SKY AND TELESCOPE, December, 1955, page 61). In order to reach the Felix Aguilar station, delegates flew first to Rio Gallegos, stayed there overnight and then flew to Lago Argentino. The bus trip from there to La Leona requires two river crossings by ferry, but it is



Standing on the steps of the 31½-inch reflector's building, these are members of the astrometry and celestial mechanics conference who gathered from four continents to discuss future work, mainly on star positions and stellar motions. All photographs with this article are courtesy Otto Struve.

The astrophysics symposium at La Plata drew its participants from Argentina, England, Mexico, and the United States. This group exchanged new views on stellar evolution, the evolution of galaxies, and the creation of the elements.

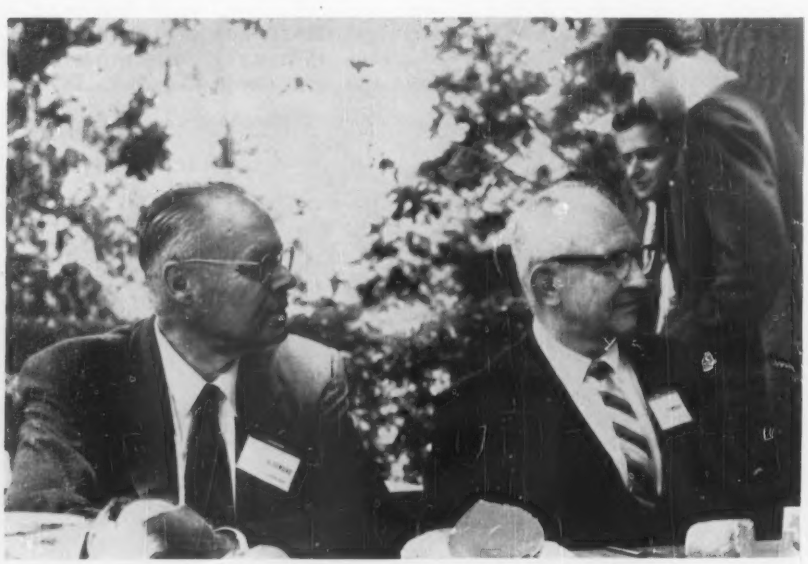
expected that communications with the station will soon be greatly improved.

At the present time, the Cape Observatory is the only one south of the equator where fundamental meridian observations are in progress, and thus the fundamental system of star positions at high southern declinations depends on work with a single instrument. The main object of the Felix Aguilar station will be to improve this situation. At its high southern latitude, nearly 50°, many southern stars are circumpolar and easily observable when on the meridian below the pole as well as above it.

Lick Observatory has made its 6-inch meridian circle available to the new station. Completely overhauled and modernized, the instrument is now being erected on piers in the solidly built meridian house. La Plata astronomers hope that the station can be in operation in two or three years.

The astrophysics symposium was arranged by Jorge Sahade, who has recently announced that the National University of La Plata has authorized the drawing up of plans to erect an 84-inch reflector, which is to be a duplicate of the one now being constructed at Kitt Peak National Observatory in Arizona. The Argentine astronomers have already ordered the blanks for the optics from Corning Glass Works.

Among the papers were two by George H. Herbig, Lick Observatory. He dealt with the contraction of stars of small mass, and presented new results on the structure and other properties of T Tauri variables and dwarf emission-line *M* stars. Such stars were also discussed by the Mexican astronomer G. Haro.



Otto Struve (left), director of the National Radio Astronomy Observatory, and Dirk Brouwer, director of Yale University Observatory, took part in the astrophysics symposium and the astrometry conference, respectively, and supplied the material on which this report is based. Both received honorary doctoral degrees from La Plata National University.

Martin Schmidt, of California Institute of Technology, reported that in the Andromeda galaxy, M31, the helium-to-hydrogen ratio is about the same in all of its ionized hydrogen (H-II) regions. He suggested that the formation of massive stars may depend upon the third power of the gas density, while the formation rate of solar-type stars may have been almost uniform. He believes that the white dwarfs in the Milky Way can comprise a substantial fraction of its total mass, and he predicted how the luminosity and color of stars in the solar neighborhood would change with time.

From Mount Wilson and Palomar Observatories, Halton C. Arp compared the properties of variable stars in the Milky Way and in the Small Magellanic Cloud. He showed that Cepheid variables in the region of the Hertzsprung-Russell diagram where stars are unstable evolve roughly along a line of constant period of pulsation. He emphasized that Magellanic Cloud giants evolve differently from those in the Milky Way system.

Also from Pasadena, Allan R. Sandage brought a new determination of the ages of the oldest galactic clusters, using F. Hoyle's most recent stellar models. For M67 in Cancer he estimates an age of from nine to 10 billion years, and for NGC 188, 16 billion years. The latter value is smaller than given in Otto Struve's article, "Ages of the Stars" in September, 1960, page 140.

Dr. Sandage pointed out that the difference between the old and new values is due to two factors: adoption of a new apparent brightness for the sun, determined by J. Stebbins and G. Kron, which leads to a solar absolute bolometric magnitude of 4.76, instead of 4.63; and a revision of the distance modulus of NGC 188 by 0.15 magnitude to correct for the slight evolution of the faintest stars from the zero-age main sequence. The first factor increases the actual luminosities of stars of a given bolometric magnitude by 14 per cent, and therefore

Geoffrey Burbidge, Yerkes Observatory, spoke on the origin of elements.

decreases the ages of all stars that were computed on the basis of a solar value of 4.63.

The ages of the oldest globular clusters are now believed to be 22×10^9 years for M13, and 26×10^9 years for M3 and M5. These ages are considerably greater than that of NGC 188, even though the breakoff point on the main sequence is almost identical for NGC 188, M3, and M5. The ages differ because the evolutionary rates depend on stellar metal abundances, which are different in globular and galactic clusters.

The new ages of both types of clusters greatly exceed the time interval since the beginning of the expansion of the universe of galaxies, which would be about 8×10^9 years, using a Hubble constant of 75 kilometers per second per megaparsec. Dr. Sandage suggested that this difference from the cluster ages might be due to incorrect nuclear evolution times. It is also possible that cosmological theory is incorrect or that the quantity called the deceleration parameter, obtained from the observed magnitude-red-shift relation, may not be correct.

Other speakers included M. Jaschek, of La Plata, on peculiar and metallic-line stars, Dr. Sahade, on the evolution of close binaries, and C. M. Varsavsky, National University of Buenos Aires, on the period-eccentricity relation for double stars. Two Yerkes astronomers, Geoffrey and Margaret Burbidge, spoke respectively on the status of nucleosynthesis theory, and some aspects of extragalactic astronomy bearing on stellar and galactic evolution. Otto Struve presented a working hypothesis regarding the evolution of galaxies that are members of large clusters, and he was called upon to summarize the symposium.

At the joint session of astrometrists and astrophysicists, Olin J. Eggen, from the Royal Greenwich Observatory, presented a paper on "Kinematical Groups of Old Stars," and S. Vasilevskis, Lick Observatory, was asked to lead the discussion.

OBSERVING THE SATELLITES

Explorer VIII and the Ionosphere

FOR MANY YEARS, the earth's ionosphere could only be studied indirectly, chiefly by its effects on radio propagation. It was found that this electrically conducting portion of the upper atmosphere is like a many-layered cage surrounding the earth; some radio frequencies can escape through the meshes of the cage, while others are reflected back to ground. These effects, which vary greatly, are largely due to the ionosphere's free electrons, liberated by solar ultraviolet radiation and X-rays.

More recently, sounding rockets and artificial satellites have obtained direct measurements of the composition of the ionosphere. Thus, Sputnik III data have shown that between 150 and 600 miles altitude the positive ions are predominantly oxygen atoms that have lost a single electron. This same satellite, when traveling in sunlight, could pick up electrons fast enough to maintain a negative potential of seven volts with respect to its surroundings. The ionosphere's F-2 layer, where free electrons are most abundant, has a few million of them per cubic centimeter. Above the F-2 layer, which is some 180 miles high, this number decreases much less rapidly than below it, according to the data from Sputnik I.

Direct exploration of the ionosphere is the principal purpose of the American satellite Explorer VIII, launched on November 3, 1960, at 5:23:10 Universal time from Cape Canaveral, by the National Aeronautics and Space Administration. The new 90.0-pound instrument package closely resembles Explorer VII, sent aloft on October 13, 1959. It is a squat cylinder, 30 inches in diameter, capped on both ends with broad cones that make the overall length also 30 inches.

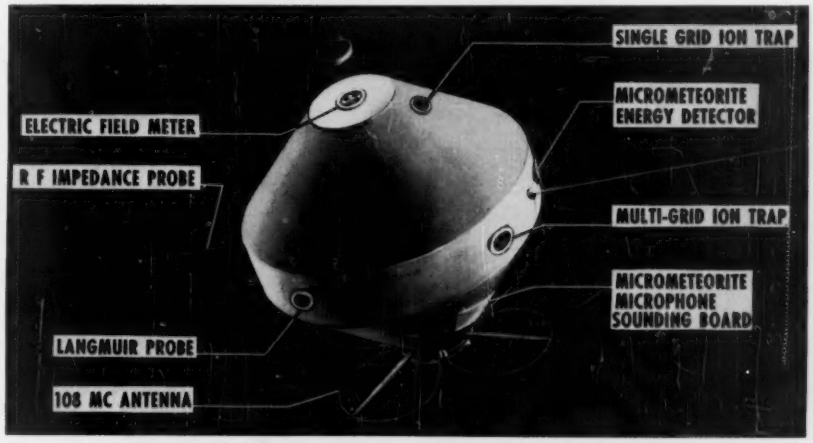
The launching vehicle was a Juno II, whose first stage consisted of a Jupiter IRBM with enlarged fuel tanks. The next three propulsion stages were powered in turn by 11, three, and one modified Sergeant solid-propellant rockets.

Since Explorer VIII was intended to investigate a wide range of altitudes, a rather eccentric orbit was achieved by allowing the vehicle to coast upward for only $4\frac{1}{2}$ minutes following the three-minute burning time of the Jupiter booster. Half a minute after coasting ended, all stages had fired, and the exhausted final rocket was separated from the payload two minutes later.

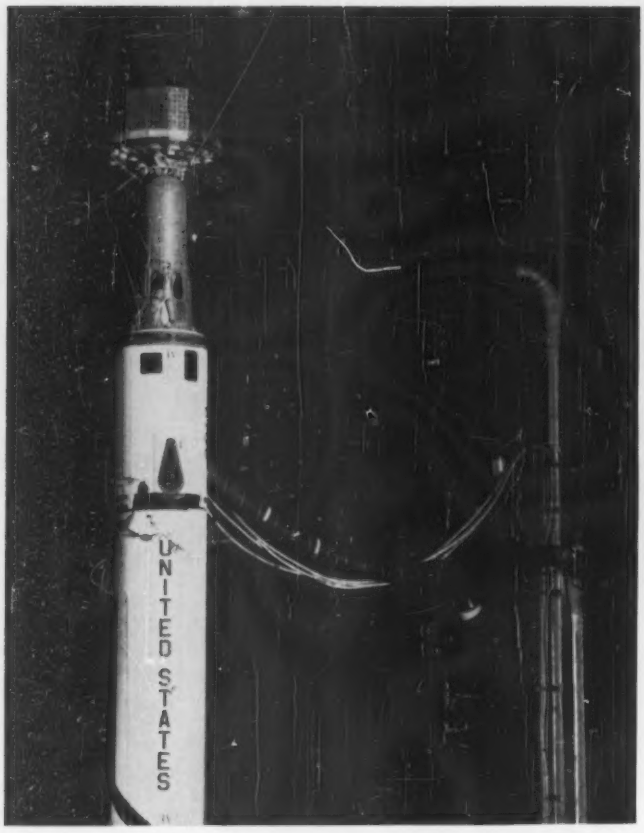
When the probe entered orbit at a relatively low perigee height of some 263 miles, it was traveling 18,145 miles an hour, fast enough to carry it up to about 1,428 miles at apogee. Closely similar orbits are being followed by the satellite (1960ξ1) and its empty rocket casing (1960ξ2), a 12-pound object measuring six by 68 inches. Both had perigee-to-perigee periods of about 112.75 minutes initially, and orbital inclinations of 50.0 degrees.

Shortly after the payload separated, it released a pair of 30-gram weights, each unwinding a 206-inch-long wire from around the satellite's midsection, thereby slowing its rotation from the initial 450 r.p.m. When the wires were fully extended, they parted from the satellite, and a second pair of weights unwound two 10-foot sections of dipole antenna. The final spin rate of the package was 30 r.p.m.

Unlike Explorer VII, the new satellite does not carry solar cells. Instead, power is provided by eight packs of mercury batteries, which together with their housings weigh 32.3 pounds. These operate the experiments, the command receiver, and the 108.00-megacycle transmitter. This last has six telemetry channels, and is expected to function continuously for



Explorer VIII, launched on November 3, 1960, is gathering information on the earth's ionosphere. This drawing is courtesy Marshall Space Flight Center, National Aeronautics and Space Administration.



Above: The new magnetic stabilization system of Tiros II weather observation satellite is being tested inside this spherical cage, designed to produce magnetic fields simulating the earth's.

Left: The top of the rocket launching vehicle of Tiros II, shown before installation of the nose fairing. This was the second successful shot in NASA's program of weather observation and forecasting feasibility studies. Both pictures courtesy NASA.

two or three months, at an average power level of 0.1 watt.

Explorer VIII carries equipment for several different kinds of measurements of conditions in the ionosphere, and for evaluating the local disturbances produced in the ionosphere by the presence of the satellite itself. The 10-foot sections of dipole antenna, already mentioned, serve as a radio-frequency impedance probe, measuring the effect of free electrons on the capacitance of the dipole.

Another instrument, called a Langmuir probe, has an insulated disk whose electrical potential with respect to the satellite's aluminum skin can be varied. The current flowing to the disk from surrounding particles is measured. At positive potentials, electrons carry a much larger part of the current than do slower-moving, heavier ions. By sweeping through a range of voltage, the speeds of the electrons can be determined, providing a measure of their temperature. This is not necessarily the same as the gas temperature, and the comparison is of much importance in ionospheric physics.

Five ion traps are mounted on the satellite to measure the mass distribution and concentration of charged particles. One trap has a single grid, mounted in front of a collector plate and flush with the satellite's skin; each of the other traps has four concentric grids and a plate.

An electric field meter, located on the axis of the payload, is used to measure the static electric field caused by the ion sheath surrounding the satellite. This experiment will allow an evaluation of electrical drag forces, which might add measurably to the resistance offered by the atmosphere. Because this equipment drains much power from the batteries, it is not operated continuously as the other experiments are, but only intermittently, on ground command.

Not all of Explorer's instruments are for ionospheric studies. There are four thermistors to measure internal and external temperatures, and an aspect indicator monitors spin and orientation. Two types of micrometeorite detectors are testing the hypothesis, suggested by Explorer I data, that many of these tiny particles are actually traveling in very elliptical orbits around the earth. In one method, calibrated microphones attached to sounding boards measure the frequency of impacts and their momenta. The other detector is a photomultiplier tube with an aluminum-coated window. This determines the brightness and duration of the flash when a micrometeorite strikes, giving information about its kinetic energy. In this way, the masses and speeds of the particles can be deduced. The relation between speed and distance from the earth should tell whether or not micrometeorites are in fact tiny natural satellites of the earth.

NASA plans further ionosphere research by other methods, including a radio-sounding satellite presently known as S-45. Probes are also scheduled for the vicinity of the moon, where Lunik II obtained evidence of an ionosphere, and for other planets.

Another Weather-Research Satellite

TIROS II, another meteorological satellite, is continuing the work of its predecessor, described here in the June, 1960, issue, page 459. The new one was launched from Cape Canaveral at 11:13:04 Universal time on November 23, 1960, by a Delta vehicle like the one used for Echo I (October issue, page 200). The final stage is in orbit as 1960π2, the weather package being 1960π1. The latter weighs 280 pounds and has the same size and shape as Tiros I; it is also fitted with the same number of solar cells (9,260).

Since the cameras worked well the first time, similar ones are being used again, but the wide-angle television system did not perform as well as expected during the first five days Tiros II was in orbit. When it failed in mid-June, Tiros I had transmitted 22,952 images, about three-fourths of them from the wide angle. For the new satellite, 85 per cent of 312 narrow-field television pictures are useful cloud records.

There are also two radiation experiments aboard the new Tiros, with a three-watt transmitter operating at 237.8 megacycles to relay their information. One

experiment has five detectors: 1. A 7-30-micron sensor to measure the infrared radiation of the earth and its atmosphere combined. 2. A more sensitive 8-12-micron unit for a "window" where the cloudless atmosphere is transparent. This device will give temperatures of cloud tops or of the earth's surface, depending on local weather conditions. 3. A monitor for a narrow band near 6.3 microns, where water vapor radiates energy.

4. A wide-band unit covers the spectrum from the ultraviolet to the near infrared, 0.2 to five microns, to measure the earth's albedo. 5. A photocell sensitive in the visible region from 0.5 to 0.7 micron provides data to correlate the other four sensor readings with the television pictures. This is needed because the cameras are set parallel to the spin axis of the satellite, while the sensors are canted 45 degrees to the axis, so the rotation will cause them to sweep strips of the earth below them.

The second radiation experiment has two sensors: one white, the other black. These measure the heat balance of the earth's area that is scanned by the wide-angle camera. Surface observations from at least 15 nations are to be correlated with the pictures and other information from the satellite.

An important new method of controlling the orientation of the spin axis is being tested with Tiros II. Surrounding its base is a coil of aluminum wire that can be energized by ground command, thus making the satellite act as a magnet. Its interaction with the earth's magnetic field will produce a torque causing the body to precess. In addition, there are five pairs of small spin rockets. On the third day in orbit, two sets were fired to increase the spin rate of Tiros II from about eight to 13.9 revolutions per minute.

The chief ground stations maintaining contact with this satellite are at Ft. Monmouth, New Jersey, and San Nicolas Island, California. Besides the three-watt transmitter, this Tiros has two 235.0-megacycle units for the television cameras and two low-power tracking beacons operating at frequencies of 108.00 and 108.03 megacycles.

In addition to the payload and its final rocket stage, two more parts, designated $\pi 3$ and $\pi 4$, are being followed by Space Track. Possibly these are the weighted cables used for reducing spin after orbit was attained.

The inclination of the orbits of all of these is about 48.6 degrees to the plane of the earth's equator. They had initial periods of revolution from node to node of 98.19, 98.14, 98.17, and 98.32 minutes, for $\pi 1$, $\pi 2$, $\pi 3$, and $\pi 4$, respectively. The first of these, the Tiros II satellite package itself, had perigee and apogee heights initially amounting to about 380 and 463 miles.

Discoverer XVII

MAJOR IMPROVEMENTS in space technology were tested for the first time with the Discoverer XVII launching from Vandenberg Air Force Base in California on November 12, 1960, at 20:42:33 Universal time. This was called "the most successful operation in the Discoverer series" by the U. S. Air Force Ballistic Missile Division, following the airplane recovery of the re-entry capsule after more than two days in space.

The orbiting vehicle was an enlarged, improved rocket. The Agena B, 25 feet long and weighing 15,500 pounds, is more than six feet longer and 7,000 pounds heavier than the Agena A. The most important advance was its new engine, which permits doubling the burning time. In the earlier model, the thrust nozzle was plugged to sustain sea-level pressure until combustion began, but in the new design an initial squirt of oxidizer into the chamber provides the needed pressure for spontaneous ignition of the fuel. This firing method permits a second start in space when necessary.

Special attention was given to stabilizing the Agena vehicle, with apparent success. When the Discoverer XVII capsule was released on the 31st revolution, it descended in plain view of four C-119 airplanes, one of which snatched it in mid-air. More elaborate equipment now permits complete control over initiating the Discoverer recovery sequence, instead of relying on preset programs as previous Discoverers had.

Fortuitously, Discoverer XVII was launched soon after a very intense solar flare had erupted, so the experimental material in the 300-pound capsule was subjected to some exceptionally heavy radiation. Biological specimens included a preparation of the human protein gamma globulin, cultures of human tissues, mold spores, and algae. A radiation dosimeter and a pack of photographic emulsions for recording nuclear particles also were aboard.

The Agena continues to travel in an orbit inclined 81.86 degrees to the earth's equator. Known as 1960$_\rho$, its initial period was 96.5 minutes, with perigee and apogee heights of 115 and 618 miles.

Sputnik VI

ANOTHER animal-carrying spaceship was placed in orbit by the Soviet Union, according to Russian press reports of last December 1st. The cabin was similar to the one successfully retrieved on August 20, 1960 (see Sky and Telescope for October, page 201, and November, page 274).

Like Sputnik V, the vehicle carried two dogs and other animals and plants. It weighed 4,563 kilograms, a little more than five tons. Its initial period was 88.6 minutes in an orbit inclined 65 degrees to the equator, according to Soviet scientists.

Space Track figures give initial perigee and apogee heights of only 116 and 160 miles, respectively, for Sputnik VI (1960$_\rho$1) with similar values for its launching rocket (1960$_\rho$2). Several hours after Space Track announced that the former was no longer in orbit, Soviet sources confirmed that an attempt had been made to recover the cabin on December 2nd, during its 18th revolution, but that it had burned up on re-entry. The rocket also entered the atmosphere either that day or early on December 3rd.

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DIAMETER OF VENUS

The precise size of the planet Venus has long been somewhat uncertain, for measurements of its disk with ordinary micrometers are subject to many kinds of systematic error. Moreover, all direct optical determinations of the diameter refer not to the solid surface of the planet, but to the heavy layer of clouds enshrouding it. A new and much more reliable result has now been derived from visual, photographic, and photoelectric observations of the occultation of Regulus by Venus on July 7, 1959 (see page 483 of Sky and Telescope for July, 1959, and page 606, September, 1959).

The data from two dozen observatories in the Eastern Hemisphere were used by G. de Vaucouleurs and D. H. Menzel of Harvard Observatory, who report their results to the British journal *Nature*.

As the planet passed in front of the star, the latter disappeared and reappeared gradually — because of differential refraction of its light by Venus' atmosphere. The Harvard astronomers chose for the duration of the occultation the interval between times of half brightness. This gave a value of 12,330 kilometers for the diameter of an atmospheric shell some 65 kilometers above the planet's clouds. For the solid globe of Venus, if the cloud top is 27 kilometers above the surface, as the temperature data suggest, the diameter is 12,146 kilometers (7,547 miles), with an uncertainty of about 12 kilometers. This is 0.952 the mean diameter of the earth, and differs little from the best previous data.

CORRECTION

On page 329 of the December, 1960, issue, the number of solar flares that had been catalogued up to the end of 1956 is given as 438. This figure, however, refers only to flares of importance 2+ or greater; it does not include the more numerous lesser events of importance 1 and 2. H. L. Bondy, Flushing, New York, quotes M. Waldmeier as saying that 927 flares were observed from 1935 to 1944.

At 2:15 p.m. Eastern standard time on September 17, 1960, Edgar Everhart, Mansfield Center, Connecticut, photographed the rare anthelion or antisun (H in the diagram opposite). It occurred on the bright parhelic circle, and through it was an oblique cross, whose arms (I and J) made an angle of 120 degrees. Twenty degrees below the anthelion was what appeared to be another arc (K). All of the photographs with this article are reproduced from Kodachrome originals.

The Solar Halo Complex of September 17, 1960

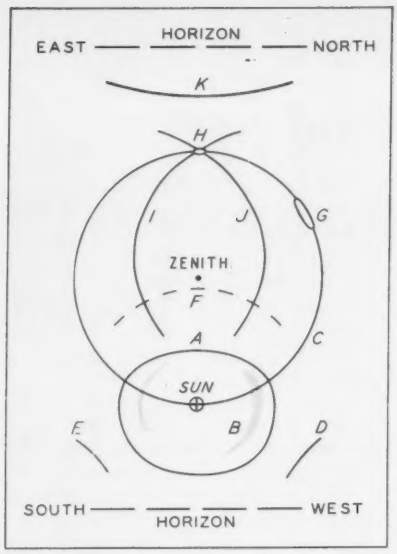
EDGAR EVERHART, *University of Connecticut*

LAST September 17th the skies over southern New England and Long Island were covered with circles, crosses, and arcs, some white and others brightly colored. These beautiful halo phenomena were caused by sunlight reflected and refracted by ice crystals high in the air.

Two of the most spectacular halo displays recorded in this country were seen on January 10, 1918, at Boulder, Colorado, and on March 8, 1920, at Ellendale, North Dakota. Descriptions of them can be found in W. J. Humphreys' *Physics of the Air* (1929). Last September's event was at least comparable to these famous cases, though all three differed from each other.

The commonest feature of halo dis-

The noncircular solar halo is seen in this picture curving from top left to bottom right. The small ring around the sun is a lens-flare effect that occurred inside the camera.



The author here identifies the features mentioned in this article, the sun being 34 degrees high, at 2:15 p.m. EST.

plays is a ring of 22 degrees radius around the sun or moon. This ring is colored red on the inside, changing to yellow and then white on the outer edge. It is caused by refraction of light through hexagonal needlelike ice crystals which sometimes occur in thin cirrus clouds. Associated phenomena, although less common, are sundogs or parhelia, 22 to 30 degrees to the right and left of the sun, and vertical sun pillars. The recent event did not have these patterns, but did show several rare, almost unique, features.

At 2:00 p.m. Eastern standard time I was alerted to the halo complex by Wilbur Widmer, and proceeded to photograph and sketch it. Kodachrome film was used with a Miranda camera having a wide-angle Travegon lens of 35-mm. focus. The exposures were 1/60 second, at f/11 toward the sun and at f/8 away from it. The color transparencies show more detail than noticed visually, and also allow angular measurements to be made.

The most prominent feature was the ring around the sun, labeled **A** in my sketch. It was not circular, nor was the sun centered vertically within it. Its top was 22 degrees from the sun, the right and left sides 30 degrees, and the bottom 28. From inside out, its colors were red, yellow, and white. In the sketch, ring **A** is drawn from the photographs and from visual observations by Mr. Widmer, Felix Yokel, Donald Richardson, Elizabeth Everhart, and myself. The first two of these had watched the display for several hours, and reported that the ring was circular at first, becoming distorted as the day progressed.

The peculiar shape of ring **A** was the most novel feature of the display, since it is not mentioned either in Humphreys' book or in M. Minnaert's *The Nature of Light and Colour in the Open Air* (1954). They refer to the *circumscribed halo* formed by upper and lower tangent arcs to the 22-degree halo, and this has a horizontal extent varying with the altitude of the sun. But a circumscribed halo should pass 22 degrees above and below the sun, and this does not agree with the observations of ring **A**.

In the original negative of the lower picture opposite, there is an indistinct boundary of 22-degree radius outside of which the sky is brighter. This appears on several other transparencies, and was also seen by Mr. Richardson. Marked **B** in the drawing, it is possibly a trace of the 22-degree halo.

The white parhelic circle, **C**, passed through the sun and extended completely around the sky, parallel to the horizon. It is caused by reflection from the vertical faces of ice crystals. Bows **D** and **E** are so-called infralateral tangent arcs to the halo of 46 degrees, caused by refraction from ice crystals with horizontal axes. They were brightly colored with red nearest the sun, followed by yellow, green, and white in that order. Though the 46-degree halo itself was missing when the photographs were taken, a faintly colored arc of it, **F**, was seen briefly a few hours earlier by Mr. Yokel, John Landry, and G. Lauria.

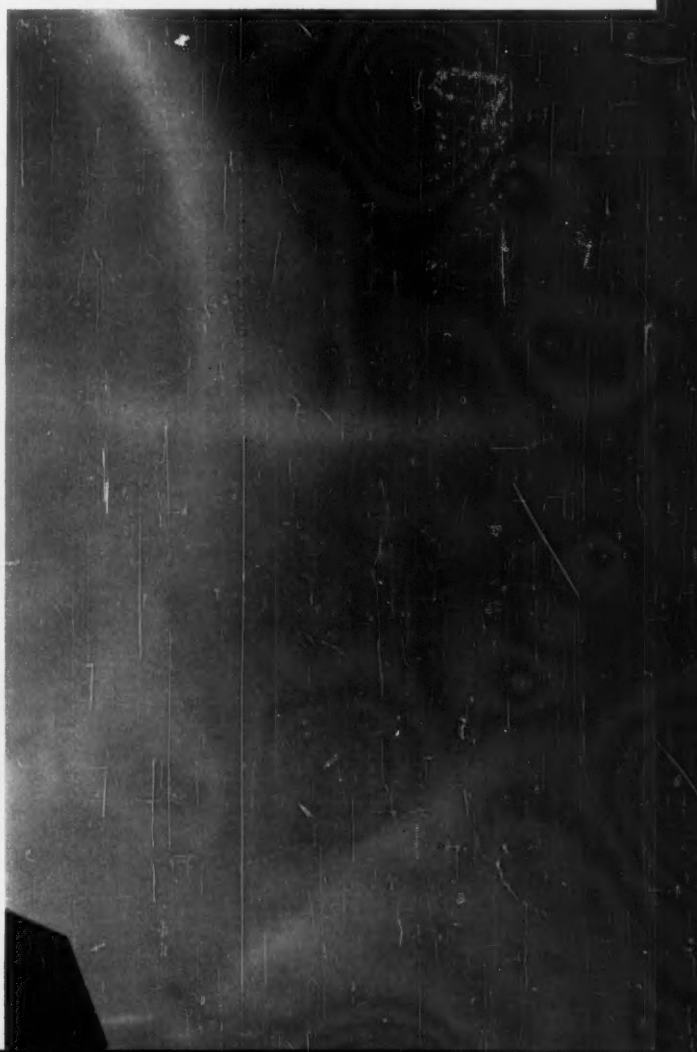
Another photograph showed a bright region **G**, 14 degrees long, centered on the parhelic circle about 120 degrees from the sun. This may have been an elongated and diffuse parhelion of 120 degrees, but was not observed visually.

The very rare anthelion or countersun appeared at **H**, opposite the sun on the parhelic circle. It was centered on a spectacular St. Andrew's cross, white against the blue sky, lasting only 15 minutes. Oblique arcs **I** and **J**, forming the cross, stretched symmetrically across the sky on either side of the zenith, nearly to ring **A**. Visually, it did not seem that they would pass, if extended, through the sun, nor did they approach **A** tangentially.

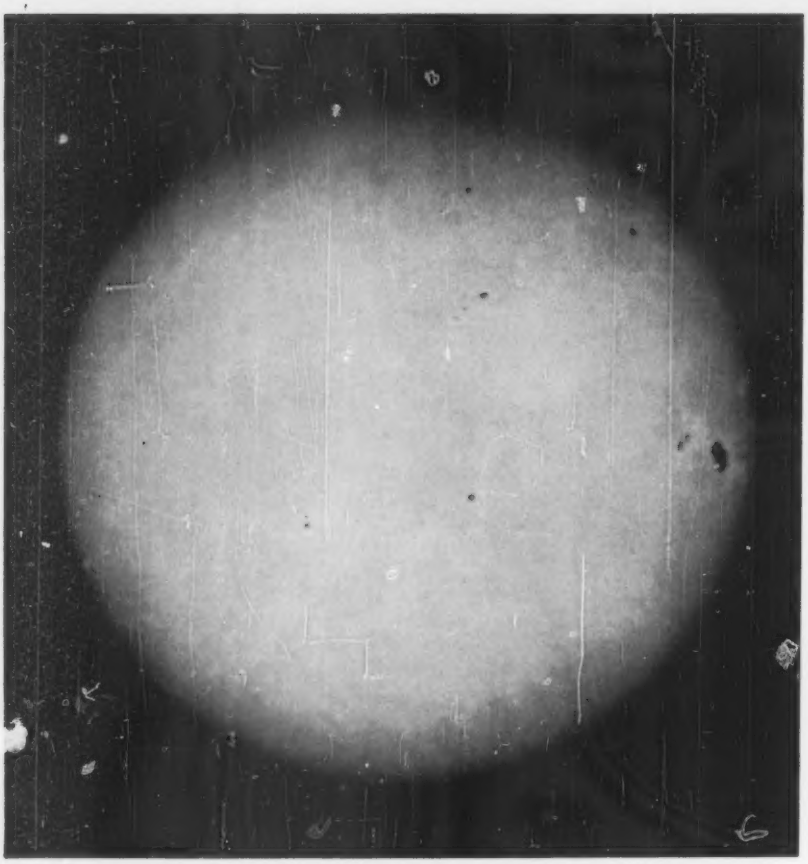
About 20 degrees below the anthelion, halfway to the horizon, was a white arc **K**. It arched slightly downward to the northwest horizon, and apparently was not centered on the antisolar point below the horizon. I have not seen any printed reference to such a feature, which may not have been a halo.

At 2:30 p.m., the entire complex suddenly faded, and the sky quickly became covered with tufts of altocumulus clouds.

ED. NOTE: Herbert A. Luft, Oakland Gardens, New York, also reported this display (see page 29).



Mr. Everhart's many photographs of the September 17th halo phenomena included this one of the intersection of the noncircular arc (upper left) with the horizontal parhelic circle (above center), while part of a tangent arc shows in the lower right. The sun is to the left (out of the picture). The side of the tangent arc D nearest it was bright red, and looked like a rainbow except that there was no blue, this color being replaced by white. The smallest distance from the arc to the sun was measured by the author as 45 degrees, plus or minus two degrees. This value agrees well with the 46 degrees expected.



Mercury appears as a small round dot near the top of the sun's disk, a half inch inside the solar outline. William C. Atkinson, New York City, took this half-second exposure on Kodak Autopositive film at 15:36:03 Universal time. His instrument was a 4½-inch Newtonian reflector. The large sunspot at the right was nearly central during the great November aurora **(see page 37).**

Findings from Mercury's Transit

JOSEPH ASHBROOK

TELESCOPES across half the world viewed and photographed Mercury's passage in front of the sun's disk on November 7, 1960. Reports have been received by SKY AND TELESCOPE of observations made in western Europe, North and South America, and as far across the Pacific as Australia.

Many correspondents had devoted particular attention to timing the contacts, the four stages of the transit when the disk of Mercury is tangent to the solar disk. Their numerous observations are tabulated here, affording rich material for analysis.

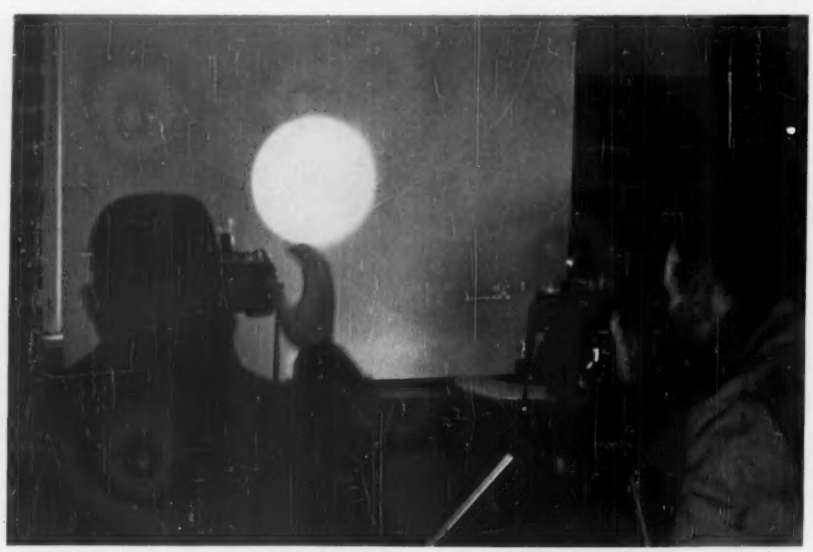
Strictly speaking, contact I is an unobservable event with ordinary telescopes, being the moment when Mercury is externally tangent to the sun. The first recognition of a visible notch in the sun's edge is necessarily later, by an unpredictable amount. At several previous transits, however, spectroscopic equipment has been used to show Mercury in silhouette against the solar chromosphere just before first contact, allowing a useful timing of this event.

Listed here are 188 timings of the other contacts, expressed as Universal times. For each, the predicted time for the observer's location has been computed from the approximate formulae on page 306 of the *American Ephemeris* for 1960. (In using those equations, the conversion from Ephemeris to Universal time has been taken as −35 seconds.) Lastly, for each observation, the difference between the observed and the computed times is given under the heading $O - C$.

A number of observations, some of excellent quality, were received too late for inclusion in this analysis. A few very discordant results were omitted; the times may have been incorrectly transcribed. All timings listed are believed to have been made with the aid of WWV or CHU radio time signals, or their equivalent.

The large table gives the observers' locations in order of longitude. Limitations of space do not permit naming of timekeepers and assistants, even though they played a vital part in the success of the program. Also, certain reports from groups listed only averages and not each individual's timings.

For contact II, there are 50 observations. Few correspondents mention having observed the black drop, the dark ligament sometimes seen connecting Mercury to the sun's edge for a brief interval at this stage. The bulk of these observations evidently refer to internal tangency,



At Macalester College, St. Paul, Minnesota, students used the horizontal telescope arrangement shown on the front cover to obtain a large projected image of the sun, allowing astronomy instructor Sherman Schultz, Jr., to demonstrate the November transit to over 200 persons.

rather than the breaking of the black drop. The unweighted average of the timings indicates that II occurred 1.8 seconds earlier than predicted. The mean error of one observation is about ±15 seconds, but the range in quality is obviously great.

Similarly, the 81 timings of contact III indicate that it took place 10.6 seconds early. Thus the duration of the transit, from II to III, comes out about nine seconds shorter than predicted. We may compare this result with that from the 1953 transit, where the interval from II to III was 27 seconds shorter than calculated. A similar discrepancy was found for the intensively observed transit of November 11, 1940. There is no straightforward explanation of these abnormally short durations, apart from systematic errors in contact timings.

There is a wide spread in the 56 tim-

Left to right, in this observing group at Lincoln High School, San Jose, California, are D. Taylor, K. Wells, C. Rubin, and G. Pritchard.

OBSERVED AND COMPUTED CONTACT TIMES FOR MERCURY'S TRANSIT — NOVEMBER 7, 1960

Key to the observer's numbers is given in the table on pages 18 and 19.

CONTACT II

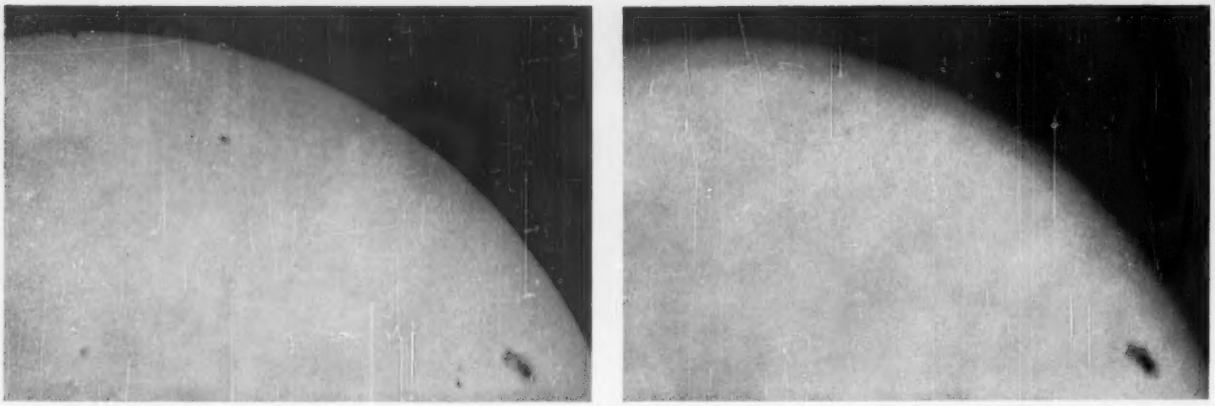
No.	Observed h m s	Computed h m s	O − C s
4	14 36 54	14 36 24	+30
5	36 17	36 26	− 9
6	36 25	36 26	− 1
9	36 18	36 28	−10
10	36 38	36 44	− 6
11	36 47	36 44	+ 3
13	36 46	36 44	+ 2
14	36 53	36 44	+ 9
15	37 04	36 44	+20
17	36 15	36 44	−29
20	36 15	36 44	−29
21	35 50	35 55	− 5
22	36 40	36 44	− 4
23	36 42	36 44	− 2
27	36 37	36 44	− 7
30	36 38	36 44	− 6
31	36 38	36 44	− 6
32	36 39	36 44	− 5
36	36 31	36 44	−13
37	36 28	36 44	−16
39	36 50	36 44	+ 6
41	36 40	36 45	− 5
42	36 34	36 44	−10
43	36 23	36 37	−14
47	36 50	36 44	+ 6
48	36 37	36 46	− 9
50	36 31	36 40	− 9
51	37 08	36 40	+28
52	36 36	36 40	− 4
54	37 21	36 42	+39
56	36 58	36 44	+14
57	36 50	36 46	+ 4
58	36 26	36 46	−20
61	36 38	36 44	− 6
64	36 34	36 46	−12
65	36 40	36 46	− 6
66	36 45	36 46	− 1
68	36 40	36 48	− 8
71	36 38	36 47	− 9
72	37 07	36 46	+21
74	36 28	36 45	−17
75	37 15	36 47	+28
78	36 40	36 44	− 4
79	36 36	36 46	−10
80	36 58	36 47	+11
83	36 14	36 45	−31
84	36 40	36 47	− 7
85	36 39	36 57	−18
86	14 36 57	14 36 44	+13
103	37 07	36 45	+22

CONTACT III

No.	Observed h m s	Computed h m s	O − C s
1	19 10 38	19 10 45	− 7
2	10 34	10 40	− 6
3	10 39	10 53	−14
7	09 09	09 23	−14
8	09 02	09 25	−23
9	09 26	09 28	− 2
12	09 27	09 36	− 9
14	09 25	09 36	−11
15	09 02	09 36	−34
17	09 14	09 36	−22
18	09 04	09 36	−32
19	09 49	09 36	+13
20	08 59	09 36	−37
21	09 38	09 41	− 3
23	09 11	09 33	−22
24	10 10	09 38	+32
25	09 43	09 37	+ 6
27	09 18	09 37	−19
29	09 19	09 37	−18
33	09 21	09 38	−17
34	09 24	09 38	−14
35	09 02	09 37	−35
36	09 23	09 37	−14
37	09 03	09 37	−34
38	09 31	09 37	− 6
39	09 14	09 37	−23
40	09 20	09 37	−17
41	09 43	09 37	+ 6
42	09 20	09 37	−17
45	09 42	09 44	− 2
46	09 22	09 39	−17
48	09 40	09 40	0
49	09 54	09 40	+14
52	09 29	09 38	− 9
53	09 33	09 38	− 5
54	09 37	09 39	− 2
55	09 15	09 43	−28
57	08 53	09 42	−49
58	09 34	09 42	− 8
59	09 32	09 42	−10
60	09 24	09 42	−18
62	09 35	09 42	− 7
63	09 30	09 44	−14
65	19 09 27	19 09 44	−17
67	09 09	09 45	−36
68	09 31	09 45	−14
69	09 30	09 45	−15
70	09 28	09 45	−17
72	09 47	09 45	+ 2
73	09 45	09 45	0
74	09 39	09 45	− 6
75	09 50	09 45	+ 5
76	09 45	09 46	− 1
77	09 44	09 46	− 2
78	09 32	09 45	−13
79	10 38	09 46	+52
81	09 43	09 47	− 4
83	09 05	09 48	−43
84	09 38	09 48	−10
86	09 24	09 49	−25
87	10 20	09 49	+31
88	09 47	09 50	− 3
89	09 46	09 51	− 5
90	09 48	09 51	− 3
91	10 42	09 51	+51
92	09 57	09 41	+16
93	09 38	09 56	−18
94	09 28	09 56	−28
95	09 01	09 56	−55
96	09 34	09 56	−22
97	09 48	09 55	− 7
98	09 42	09 56	−14
99	09 55	09 56	− 1
100	10 25	10 03	+22
101	09 13	10 04	−51
102	10 10	10 05	+ 5
103	10 00	10 06	− 6
104	10 05	10 06	− 1
105	09 54	10 04	−10
106	10 02	10 07	− 5
107	09 51	10 36	−45

CONTACT IV

No.	Observed h m s	Computed h m s	O − C s
3	19 12 22	19 12 53	−31
8	11 39	11 25	+14
9	11 27	11 29	− 2
15	11 06	11 37	−31
16	10 54	11 37	−43
18	10 39	11 37	−58
19	11 06	11 37	−31
21	11 20	11 41	−21
25	19 11 18	19 11 38	−20
27	11 25	11 38	−13
28	11 25	11 38	−13
32	11 20	11 38	−18
33	11 14	11 38	−24
34	11 22	11 38	−16
35	11 39	11 38	+ 1
36	11 15	11 38	−23
37	11 03	11 38	−35
38	11 18	11 38	−20
41	11 17	11 38	−21
45	11 19	11 44	−25
48	11 35	11 41	− 6
52	11 28	11 38	−10
54	11 09	11 40	−31
58	11 23	11 43	−20
59	11 26	11 42	−16
60	11 24	11 42	−18
63	11 06	11 44	−38
65	11 22	11 45	−23
66	11 20	11 45	−25
67	10 56	11 45	−49
68	11 28	11 46	−18
72	11 24	11 46	−22
74	11 31	11 46	−15
76	11 20	11 46	−26
77	11 38	11 46	− 8
78	11 25	11 45	−20
79	12 35	11 46	+49
81	11 36	11 48	−12
83	11 11	11 49	−38
85	11 37	11 49	−12
86	11 28	11 49	−21
87	11 30	11 50	−20
88	11 47	11 51	− 4
89	11 21	11 51	−30
90	11 38	11 51	−13
91	12 32	11 51	+41
92	11 42	11 41	+ 1
93	11 18	11 56	−38
97	11 48	11 56	− 8
99	12 41	11 57	+44
100	11 17	12 03	−46
101	11 58	12 04	− 6
102	11 53	12 06	−13
103	11 58	12 06	− 8
104	11 59	12 06	− 7
105	11 58	12 04	− 6
106	11 52	12 07	−15



Two views of Mercury (upper left) during ingress. That at the left was taken by Rev. Edward F. Jenkins and George McCook at Villanova, Pennsylvania, with a 6-inch refractor at 14:36:36 UT. The right-hand picture was made at 14:37:30 by Philip J. Del Vecchio, Paterson, New Jersey, with a 2.4-inch. In each case, the sun's image was projected.

LIST OF OBSERVERS OF MERCURY'S TRANSIT — NOVEMBER 7, 1960

No.	*Place*	*Longitude* ° ′	*Latitude* ° ′	*Observer*	*Telescope and Remarks*
1	Auckland, New Zealand	−174 46	−36 51	C. Corban	3L
2	Dunedin, New Zealand	−170 31	−45 53	A. Doig	12M
3	Tweed Heads, Australia	−153 35	−28 11	C. Monks	3½L, 120x
4	Mol-Donk, Belgium	− 5 04	51 13	R. Vanhaelewijn	With D. Rush
5	London, England	0 14	51 37	J. Tatum	5L, 19P, Univ. of London Obs.
6	London, England	0 15	51 30	J. Larad	3L
7	Cel. Fabriciano-Usiminas, Brazil	42 33	−19 32	J. Stout	8M, 36P
8	Lavras, Brazil	45 00	−21 15	Unnamed	8M, Lavras Obs.
9	Caracas, Venezuela	66 50	−10 29	L. Corrales	6M
10	Woods Hole, Mass.	70 40	41 32	R. Edwards	2½L
11	Milton, Mass.	71 04	42 15	K. Aschenbloss	5½L, 8P, Stearns Obs., Milton Acad.
12	Milton, Mass.	71 04	42 15	H. Stubbs	5½L, 8P, Stearns Obs., Milton Acad.
13	Milton, Mass.	71 04	42 15	S. Alsop	5½L, 8P, Stearns Obs., Milton Acad.
14	Milton, Mass.	71 04	42 15	J. Page	5½L, 8P, Stearns Obs., Milton Acad.
15	Winchester, Mass.	71 08	42 27	B. Ross	5M, P
16	Cambridge, Mass.	71 08	42 23	C. Federer, Jr.	4M, 5P
17	Cambridge, Mass.	71 08	42 23	G. Carney	4M, 5P
18	Cambridge, Mass.	71 08	42 23	R. Watts	4M, 5P
19	Cambridge, Mass.	71 08	42 23	W. Shawcross	6M, 90x
20	Cambridge, Mass.	71 08	42 23	J. Ashbrook	3L, 60x
21	Valparaiso, Chile	71 29	−33 02	Several	Soc. Astr. de Valparaiso
22	Storrs, Conn.	72 15	41 49	Several	8M, 202x, Physics Dept., Univ. of Conn.
23	Bridgewater, Conn.	73 17	41 30	L. Fraser	4L, 50x
24	Albany, N. Y.	73 47	42 39	H. Bowman	3½C
25	New York, N. Y.	73 50	40 40	S. Zuzze	2¼L, co-ordinates uncertain
26	Catskill, N. Y.	73 51	42 15	B. Weaver	6M
27	New York, N. Y.	73 52	40 53	W. Glenn	3½L, 6P
28	New York, N. Y.	73 52	40 53	E. Sicignano	3½L, 6P
29	New York, N. Y.	73 52	40 53	L. Katz	3½L, 6P
30	New York, N. Y.	73 52	40 53	D. Heisler	3½L, 6P
31	New York, N. Y.	73 52	40 53	G. Hagen	3½L, 6P
32	New York, N. Y.	73 54	40 53	Several	8M, Kada Obs., Amateur Ast. Assn.
33	Schenectady, N. Y.	73 56	42 49	Several	6M and other instruments, Mt. Pleasant H. S.
34	Schenectady, N. Y.	73 56	42 49	Several	4M and other instruments, Bp. Gibbons H. S.
35	New York, N. Y.	73 56	40 38	J. Pazmino	3M, P
36	New York, N. Y.	73 57	40 38	Several	7L, 12P, Brooklyn Coll. Obs.
37	New York, N. Y.	74 02	40 38	R. Seely	6M, 5P
38	Union City, N. J.	74 03	40 46	R. Wurgel	6M, 75x
39	Madison, N. J.	74 26	40 47	Several	3L, 6P, Fairleigh Dickinson Univ.
40	Madison, N. J.	74 26	40 47	H. Gage	L, P
41	Cliffside Park, N. J.	74 36	40 48	Several	4L, Cliffside Stellar Research Group
42	Feasterville, Pa.	75 01	40 08	R. Platt	3½C, 80x
43	Philadelphia, Pa.	75 14	40 04	G. Foley	6M, 72x
44	Luzerne, Pa.	76 54	41 17	Several	Blue Ridge Ast. Club
45	Richmond, Va.	77 26	37 34	B. Ragland	3L, 71x
46	State College, Pa.	77 54	40 47	D. Whitmarsh	
47	Charlottesville, Va.	78 30	38 03	J. Berry	4L, P
48	Buffalo, N. Y.	78 46	42 57	C. Chapman	3½C, 80x
49	Buffalo, N. Y.	78 51	42 54	E. Both	8L, 250x, with L. Reinagel
50	Jupiter, Fla.	80 07	27 01	R. Citron	8M, 12P

ings of contact IV. The last visible trace of Mercury as it leaves the sun is lost sooner by viewers with smaller telescopes or poor seeing. The mean of the 56 $O - C$ values is -16.6 seconds, indicating that as a rule the planet was last recognizable about a quarter of a minute before predicted external tangency.

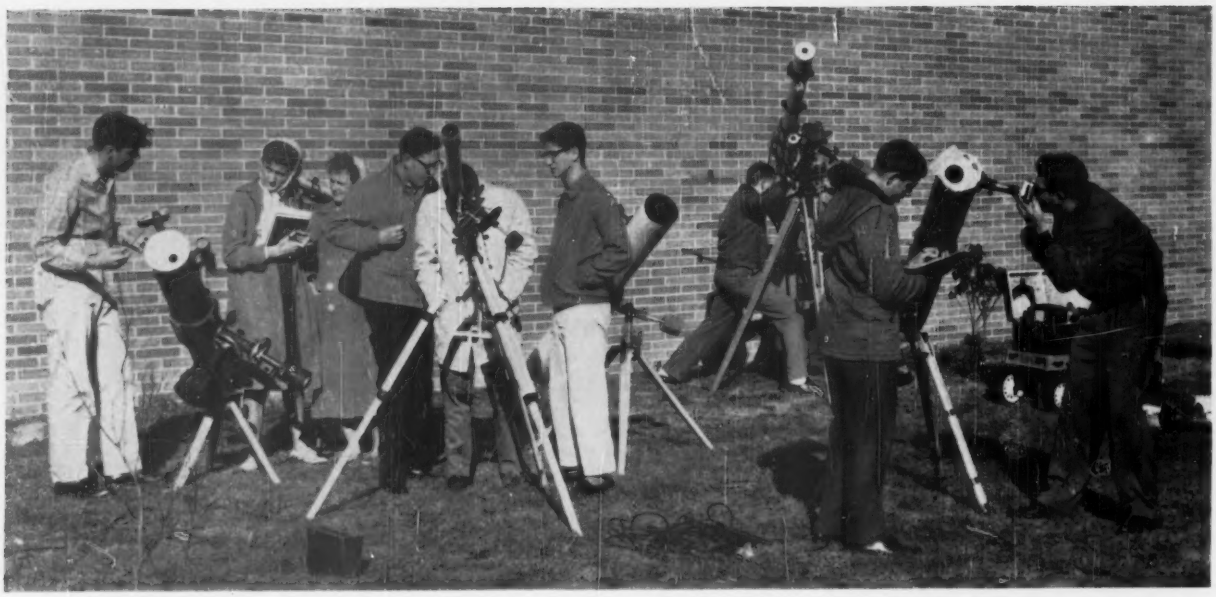
Another type of observation that can be made during a transit of Mercury is a determination of the planet's diameter. While projected on the solar disk, the angle subtended by Mercury can be measured with a filar micrometer, or even more precisely with a double-image one.

At Pan American College Observatory, Edinburg, Texas, P. R. Engle and G. Kraus each made 10 micrometer measures, with a 6-inch reflector, finding 10.12 seconds of arc for Mercury's diameter. L. B. Abbey, Jr., from 14 measures at Bradley Observatory, Decatur, Georgia, obtained 10.40.

In principle, we can also deduce the size of Mercury from the observed time interval between contacts III and IV. Ordinary contact observations are not suitable, since IV in particular is liable to systematic errors. But G. de Vaucouleurs and his coworkers at Austin, Texas, tried a special method with the 9-inch refractor of the University of Texas' student observatory. On a projected image of the sun 20 inches across, they made repeated estimates of the distance of Mercury from the sun's limb during the last three minutes of the transit, evaluating the contact times by extrapolation. Their result was that 118.7 seconds of

No.	*Place*	*Longitude* ° ′	*Latitude* ° ′	*Observer*	*Telescope and Remarks*
51	Miami, Fla.	80 12	25 50	Several	Southern Cross Ast. Soc.
52	Miami, Fla.	80 13	25 45	Several	5L, Southern Cross Ast. Soc.
53	Miami, Fla.	80 13	25 45	Several	10½M, P, Southern Cross Ast. Soc.
54	Winter Park, Fla.	81 33	28 33	J. Ross	3½C, 80x
55	Bay Port, Mich.	83 23	43 50	T. Baur	6M, with L. Murray
56	Knoxville, Tenn.	83 56	35 57	J. Brown	4L, 40x
57	Evendale, Ohio	84 00	39 41	J. Kuecken	1¾L, 5P
58	Columbus Grove, Ohio	84 05	40 53	K. Volkmer	6M, 45x
59	Decatur, Ga.	84 18	33 56	L. Abbey, Jr.	4¼L, 273x, Bradley Obs.
60	Decatur, Ga.	84 18	33 56	W. Calder	6L, 150x, Bradley Obs.
61	Decatur, Ga.	84 18	33 56	H. Hudson	5L, 200x, Bradley Obs.
62	Decatur, Ga.	84 18	33 56	M. Rushton	3½C, 150x, Bradley Obs.
63	Battle Creek, Mich.	85 13	42 16	A. Morehouse	4L, 2L
64	Indianapolis, Ind.	86 10	39 46	F. Smith	2L, 20x
65	Terre Haute, Ind.	87 23	39 28	G. Mitchell	6M
66	Terre Haute, Ind.	87 24	39 30	L. Deming	8M, 98x
67	Chicago, Ill.	87 40	42 01	P. Nachman	3L
68	Racine, Wis.	87 51	42 44	W. DuVall	8M
69	Milwaukee, Wis.	87 56	43 06	D. Haaya	
70	Milwaukee, Wis.	87 56	43 06	T. Juergens	
71	W. Allis, Wis.	88 01	43 00	R. Wend	3½C
72	Menomonee Falls, Wis.	88 07	43 11	P. Glaser	6M, 6P
73	Menomonee Falls, Wis.	88 07	43 11	R. Fink	6M, 6P
74	Milwaukee, Wis.	88 09	42 58	Several	13M, Milwaukee Ast. Soc.
75	Waukesha, Wis.	88 14	43 02	G. Wagner	4M, P
76	Oshkosh, Wis.	88 33	44 02	R. Buckstaff	3L
77	Oshkosh, Wis.	88 33	44 02	T. Schmidt	5L
78	Metairie, La.	90 09	30 00	M. Guidry	6M
79	St. Louis, Mo.	90 12	38 38	H. Lang	3L, 66x
80	O'Fallon, Mo.	90 46	38 48	R. Cox	5L, P
81	Iowa City, Iowa	91 32	41 40	Several	5L, 24P, State Univ. of Iowa Obs.
82	Little Rock, Ark.	92 20	34 44	M. Crist	3L, 42x, 100x
83	St. Paul, Minn.	93 06	44 57	Several	6M, Macalester Coll.
84	Des Moines, Iowa	93 41	41 36	P. Riggs	8¼L, 120x, 180x, Drake Univ. Obs.
85	Independence, Mo.	94 27	39 03	R. Sandy	6M, 70x, with J. Redford
86	Houston, Tex.	95 26	29 42	K. Thomson	4M, 18P
87	Topeka, Kan.	95 40	39 03	J. Starbird	6M, 45x
88	Austin, Tex.	97 44	30 17	G. de Vaucouleurs	9L, 20P, Univ. of Tex.
89	Edinburg, Tex.	98 16	26 19	W. Haas	17M, 120x
90	Edinburg, Tex.	98 16	26 19	G. Kraus	6M, 360x
91	Randolph AFB, Tex.	98 17	29 32	R. Shayler	8M, 110x
92	San Antonio, Tex.	98 34	29 27	Several	10¾L, 215x, St. Mary's Univ.
93	Regina, Sask.	104 36	50 26	L. Antonini	2½L
94	Regina, Sask.	104 36	50 26	B. Ramsay	2½L
95	Regina, Sask.	104 36	50 26	B. Drew	2½L
96	Regina, Sask.	104 36	50 26	J. Hodges	4L
97	Denver, Colo.	104 57	39 41	Several	20L, P, Denver Ast. Soc.
98	Boulder, Colo.	105 14	39 59	C. Johnson	4M, 135x
99	University Park, N. M.	106 44	32 17	Several	12M, N. M. State Univ.
100	Las Vegas, Nev.	115 09	36 10	T. Constanten	3¼L, 3¼P
101	Los Angeles, Calif.	116 33	34 21	F. Larson	3L, 66x
102	Hollywood, Calif.	118 19	34 06	A. McClure	2½L, 85x
103	Manhattan Beach, Calif.	118 24	32 53	J. Eastman, Jr.	6M, 70x; 12½M, 135x
104	Manhattan Beach, Calif.	118 24	32 53	M. Gardner	2½L, 150x
105	Kelowna, B. C.	119 29	49 53	J. Tanner	2½L, P
106	Templeton, Calif.	120 50	35 33	W. York	6M
107	Honolulu, Hawaii	157 56	21 20	M. Morrow	6M, 96x

Nos. 1, 2, 3, 7, 8, 9, and 21 are south latitude; the rest, north latitude. Under *Telescope and Remarks*, the first figure is aperture to the nearest ¼ inch; L, refractor, M, reflector, C, catadioptric; magnification, or diameter of projected image, P, in inches.



A daytime event such as the transit of Mercury makes an excellent student observing project. This setup was employed by the astronomy club of Oceanside High School on Long Island, New York. Photograph by Peter A. Leavens.

time elapsed between contacts III and IV. The distance between the centers of Mercury and the sun was then increasing by 0.08395 second of arc per second of time. We divide the 118.7 seconds by this rate to derive the diameter of Mercury as 9.96 seconds of arc. This agrees closely with the figure 9.90 cited in the *American Ephemeris* for the time of the transit. The result is a linear diameter of 3,030 miles, with a probable uncertainty of only a few per cent. (The Engle-Kraus and Abbey micrometer diameters have mean errors of about ±10 per cent.)

There has been much recent controversy about the size of Mercury. The many micrometer measurements made before 1930 lead to a diameter of 3,200 miles, according to Soviet astronomer V. Scharonov. On the other hand, both P. Muller and H. Camichel in France recently obtained 2,900 miles with special micrometers. The diameter just deduced from Dr. de Vaucouleurs' work falls inside this range.

The next transit of Mercury is scheduled for May 9, 1970. With the experience of last November's event still fresh, now is a good time to think about new methods and kinds of observations to try in 1970.

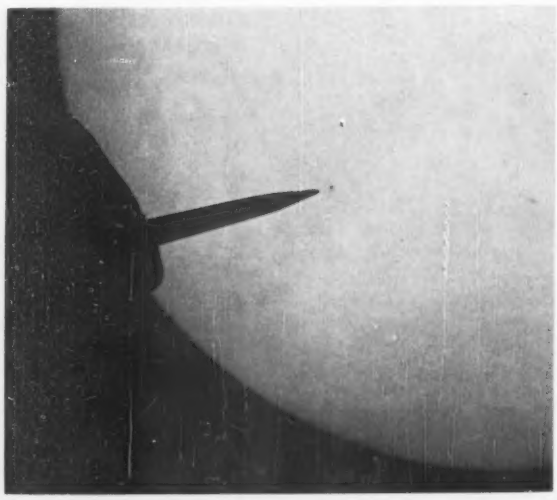
A short supplement to the list of contact times observed on November 7, 1960, will appear in the February issue.

In addition to those correspondents mentioned in this article or on page 319 of last month, SKY AND TELESCOPE extends its thanks to the following persons who have submitted reports of the transit, and to those who shared in their observations. Asterisks indicate photographic contributions.

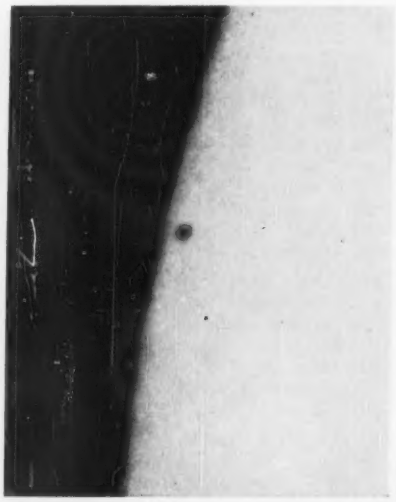
*W. Amey and others, Hagerstown, Md.; *W. Atkinson, New York, N. Y.; *A. Burstiner, Etters, Pa.; *A. Butera, Port Jefferson, N. Y.; *W. Close, Decatur, Ga.; *E. Everhart and D. Flinchbaugh, Mansfield Center, Conn.; T. Ferris and C. Goodwin, Key Biscayne, Fla.; *R. Finton, Findlay, Ohio; M. Fisher, Cheney, Wash.; W. Garrison, Muscle Shoals, Ala.; *J. Govi and others, Buenos Aires, Argentina.

*Rev. E. Jenkins and G. McCook, Villanova, Pa.; F. Kelly and others, St. Petersburg, Fla.; R. Klug, Butler, Pa.; *P. Leavens, Freeport, N. Y.; *J. Loudon, Philadelphia, Pa.; J. Marsengill and L. Pushkarsky, Trenton, Mo.; *L. Matteson, Jr., and others, Houston, Tex.; *J. Mello and others, Belo Horizonte, Brazil; *M. Meyerhoff, Glen Burnie, Md.; C. Munoz F., Villa Alemana, Chile.

L. Nadeau, Gardner, Mass.; *L. Nettleton and E. Heideman, Pleasantville, N. Y.; S. Pauley, Jr., and others, Greenwood, R. I.; G. Rippen, Madison, Wis.; *W. Mraz, Elmhurst, Ill.; *M. Schulze and others, Bergenfield, N. J.; *R. Stein, Newark, N. J.; *E. Turco and others, Cranston, R. I.; *H. Vernon and L. Glasser, Wilmington, Del.; *K. Wells, San Jose, Calif.



Left: The pencil points to the projected image of Mercury, its apparent diameter being 1/190 the sun's. Richard A. Gross, Iowa City, Iowa, used a 5-inch refractor and an Agfa reflex camera, 1/60 second at f/4.



Right: A cloud gap just before third contact enabled Edgar Everhart and David Flinchbaugh to take this transit photograph at 19:10 UT. It was made at the prime focus of the 10-inch f/11 reflector, Wormwood Hill Observatory, Mansfield Center, Connecticut.

Some Problems of Stellar Rotation — II

OTTO STRUVE, *National Radio Astronomy Observatory**

AS TOLD last month, the rotation of a star can be inferred from the broadening of its spectral lines. Observations have demonstrated that equatorial speeds of rotation of 100 kilometers per second are typical of the hotter stars (spectral types *O*, *B*, and *A*). The much more numerous cooler stars spin at considerably slower rates as a rule.

These facts are difficult to reconcile with the generally adopted view that the stars were formed by the condensation of very large, rarefied clouds of dust and gas. Internal motions in such a cosmic cloud would cause the resulting star to rotate much more rapidly than is actually observed, if angular momentum is conserved as the cloud contracts.

This difficulty is lucidly stated by Lyman Spitzer, Jr., in his chapter on star formation which will appear in Vol. 7 of G. P. Kuiper's forthcoming *Compendium of Astronomy and Astrophysics*. The Princeton astronomer writes:

"In the earliest discussions of star formation it was realized that angular momentum posed serious problems in the theory of condensation. In the absence of external torques the rotational velocity of a mass of gas varies inversely as the radius *R*. Stars of early spectral type are observed to rotate at speeds of about 100 km/sec. Since the present mean density of these stars exceeds the density of interstellar clouds by a factor of at least 10^{21}, their radii are less by a factor 10^7 than they were before contraction began. Two possibilities are present. Either the initial angular momentum per unit mass was very low, corresponding to the extremely low velocity of 1 cm/sec, or else the angular momentum has been decreased by some process. Since the turbulent velocities in the interstellar medium are probably at least 0.1 km/sec, in a cloud with a mass of several suns, it seems unlikely that much material can be sufficiently quiescent to condense into stars without loss of angular momentum. . . ."

Like Spitzer, most investigators have assumed that during a star's contraction a large fraction of the angular momentum of the primordial interstellar cloud is lost. C. F. von Weizsäcker in 1947 suggested that a rotating protostar forms a concentration in a gaseous medium, all in turbulent motion. As a result of the turbulent viscosity, the rotation of the star itself is retarded, and the excess angular momentum is carried away to the outer parts of the gaseous envelope. The latter could then form a rapidly rotating disk from which the planets and their satellites could develop. However, Spitzer and others have concluded that von Weizsäcker's process would not be adequate to explain the slow axial rotations of the cooler dwarf stars.

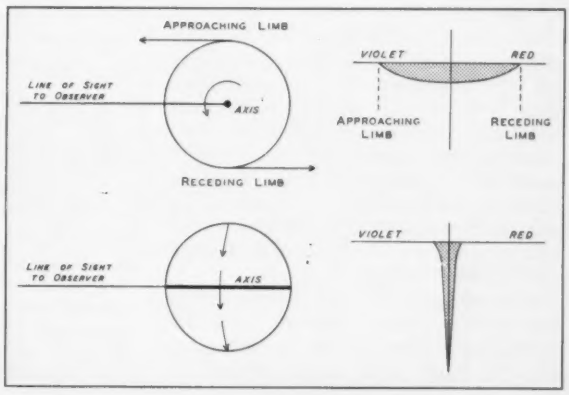
Another possibility was first suggested by the Soviet astronomer V. G. Fessenkov and later discussed in detail by E. Schatzman in France. Stars of early spectral class might lose a large amount of mass from their surface layers, which carry most of the angular momentum, by a process Fessenkov termed *corpuscular radiation*. But Schatzman pointed out that a fast-rotating star of spectral type *A* evolving to a slowly rotating *F* star would have to lose about half its mass. So drastic a loss of material, if it actually occurred, would probably not escape direct observation. Furthermore, Fessenkov's theory does not explain why there is such a sharp difference between stars earlier and later than spectral class *F2*, the former rotating rapidly, the latter slowly. This discontinuity is particularly striking in visual binary stars having main-sequence components of different spectral type. A component later than *F2* invariably shows a very small velocity of rotation, while a hotter member often, but not always, rotates faster.

Several authors have advanced hypotheses based upon the interaction of the rapidly rotating equatorial layers of a star with a magnetic field — either interstellar or belonging to the star itself. I believe that the first theory of this sort was advanced by H. Alfvén of Sweden in 1942. He assumed that the interstellar medium was ionized in the neighborhood of the star, whose magnetic field turned with it around an axis approximately coincident with the rotational axis. If, at the beginning, the ionized medium did not take part in the star's rotation, induced electric currents would be set up in it. The magnetic field of the star would cause the interstellar medium to rotate more and more rapidly, while the spinning of the star itself would be retarded.

Similar hypotheses involving magnetic coupling have been explored theoretically by R. Lüst and A. Schlüter in 1955 and by L. Mestel in 1959. Schatzman is of the opinion that these processes are too slow and inefficient. A more effective means of removing angular momentum from a star by magnetic interaction was advanced last year by R. Ebert in Germany. From an over-all view of these suggestions Spitzer concludes: "While detailed proof is still lacking, we may reasonably adopt the working hypothesis that a magnetic field can effectively reduce the angular momentum and permit the contraction of clouds into stars."

As I now see the problem of stellar rotation, there are some indications that the angular momenta of the T Tauri stars (see page 327 last month) have been retained during the contraction process, and there are even stronger reasons for believing that early-type stars leaving the main sequence and evolving into giants conserve their angular momenta. But late-type stars (including the T Tauri objects) remain in the contracting stage for billions of years, while very massive *O* and *B* stars may take only a million years to reach the main sequence. This suggests that a mechanism for removing angular momentum from rapidly rotating newborn stars is more likely to have a marked effect on those of later types.

All of the suggestions we have discussed for slowing down stellar rotation have failed to explain the discontinuity at *F2* between rapidly and slowly turning stars. However, this phenomenon is perhaps accounted for by a mechanism



Rotational broadening of a star's spectral lines depends on the apparent orientation of the axis of rotation as well as on the rate of spin. Here the circles represent rotating stars, shaded areas the profiles of their spectral lines. The top star's axis is perpendicular to the line of sight, and broadening occurs. Below, with the axis in the line of sight, the line is narrow.

*Operated by the Associated Universities, Inc., under contract with the National Science Foundation.

proposed by Schatzman in 1958 at the International Astronomical Union's Paris symposium on the H-R diagram.

Consider, said the French astronomer, a star with a pair of "sunspots," 100,000 kilometers apart, each with a magnetic field intensity of 10,000 gauss but with opposite polarities. Extending outward from each spot to a great distance above the surface of the star, the lines of force would be almost radial. A puff of rarefied gas, ejected at high speed from one of the spots, would be highly ionized and would therefore travel far outward along the lines of force. Being compelled by the field to turn with the star, the mass of gas would acquire more and more angular momentum at the expense of the magnetic field.

The nearly radial lines of force extend to distances much greater than the radius of the star, but ultimately loop back to the other spot. In the region where the lines of force are strongly curved, the fast-moving ionized gases can no longer be restrained by the magnetic field and would be lost to the star. Schatzman has computed that, under reasonable assumptions concerning the magnetic fields of the spots and the mass and density of the expelled gas, much angular momentum can be carried away from the star, and that it is even possible for the rotation to approach zero.

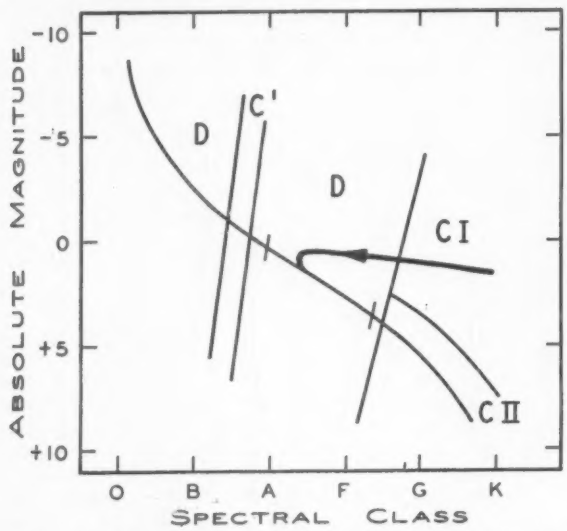
In a recent Mount Wilson and Palomar Observatories technical report, Schatzman has applied this idea to stars of different spectral types. He points out that activity like that of sunspots is probably connected with the so-called *convective zones* in the outermost layers of stars, where turbulent motions exist. These zones are produced by the ionization of hydrogen and are located near the surface for stars of spectral class *F*.

Schatzman has drawn the accompanying Hertzsprung-Russell diagram, in which the region labeled **C I** is the domain of stars in which spot activity should be prominent. For such stars, Schatzman's mechanism would work; rapidly rotating stars would lose angular momentum. The diagram shows the evolutionary track of a star that reaches the main sequence at spectral class *A*. Where the track is in region **C I,** the star's rotation will be braked. In region **D,** stars have no convective zones and presumably no spots. There Schatzman's mechanism would not operate, and the star would retain its angular momentum until reaching the main sequence.

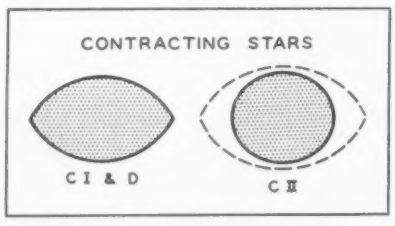
The diagram shows another narrow strip, **C′**, where stars can have surface convective zones produced by the ionization of helium. Though a star passing through **C′** will also experience loss of angular momentum, the effect is probably small because the strip is so narrow.

From theoretical grounds, Schatzman suggests that in **C I** stars lose mass at their equators, while in **C II** mass loss occurs only through surface activity. This should influence the shapes of the stars in different parts of the H-R diagram, as Schatzman's sketch shows. His recent paper contains additional details, many of which agree with observational data.

One great unresolved difficulty is that the number of slowly rotating *O, B,* and *A* stars is greater than follows from Schatzman's theory. In other words, there are many more of these stars with small *observed* rotational velocities than we should expect from a sample of stars with large *true* rotational velocities, if we assume randomly oriented axes of rotation. Inescapably, there must be many early-type stars that have small true equatorial speeds. Their number is also too great to be explained by W. H. McCrea's theory, outlined on page 328 last month. Their existence does not seem to be explained by Schatzman's present hypothesis or, for that matter, by any other hypothesis advanced to date.



E. Schatzman drew this spectrum-luminosity diagram to indicate which stars can lose angular momentum. Those in areas C I and C II (but not D) should have surface activity, thus ejecting mass and losing momentum. The arrowed line is the evolutionary track of a star contracting to the main sequence, which extends from the upper left to lower right.



According to Dr. Schatzman, contracting stars in region C I should be shaped as at the left, those in C II as at the right. Both diagrams on this page are from Mount Wilson and Palomar Observatories.

IMPROVING THE PERFORMANCE OF A LARGE REFRACTOR

Since 1893, Greenwich Observatory has used its 28-inch f/12 visual refractor for double star observations. Although the instrument's resolving power equals its theoretical value, it was always surprisingly difficult to measure close pairs fainter than 8th magnitude. In the September, 1960, issue of the *Quarterly Journal* of the Royal Astronomical Society, R. v. d. R. Woolley (the Astronomer Royal) tells how this defect has recently been corrected.

". . . The objective was tested by Hartmann's method, and was found to be slightly over-corrected. Hartmann's constant was satisfactorily small (0.3), but a detailed calculation of the diffraction image then showed that the central intensity was only 60 per cent of that of the theoretical Airy disk. Ray tracing indicated that the over-correction could be removed by a slight further separation of the lenses, and an additional 0.28 inch was adopted after further trials. The spherical aberration then virtually vanished except for a small zone of slightly longer focal length near the centre of the lens, and Hartmann's constant over thirteen zones was found to be 0.05 compared to 0.16 for the Yerkes 40-inch, the best large object glass for which information was available. The resulting distortion of the colour curve was estimated as moving the peak 100 angstroms towards the blue."

CONSTELLATION SIZES

The five largest constellations are Hydra, with an area of 1,303 square degrees; Virgo, 1,294; Ursa Major, 1,280; Cetus, 1,231; and Hercules, 1,225. These figures are from a list by A. E. Levin of the sizes of all 89 presently recognized star groups (the two separate portions of Serpens being counted individually), published in the 1961 *Handbook* of the British Astronomical Association. According to the same tabulation, first published in the *Handbook* for 1935, the smallest constellations are Sagitta, Equuleus, and Crux, with areas of 80, 72, and 68 square degrees, respectively.

If such a compilation had been attempted 200 years ago, first place would have gone to the southern group Argo, covering about 1,900 square degrees, which has since been divided into Puppis, Carina, Vela, and Pyxis.

LETTERS

Sir:

In the November, 1960, issue (page 259), Dr. Otto Struve reports, from an advance copy, on an article by I. S. Shklovsky in which it is suggested that Cygnus A might be interpreted as a peculiar single galaxy resembling NGC 5128, with a broad band of obscuration across it. This interpretation is definitely in contradiction to observational facts; the claim that the two objects are similar has no foundation.

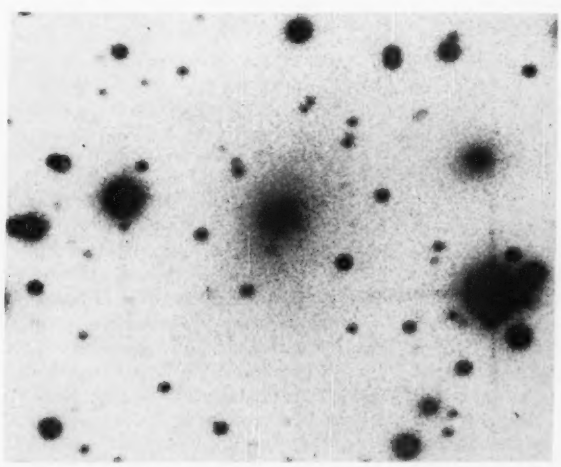
The broad irregular dark band crossing the center of NGC 5128 is quite obviously a distorted flattened system or subsystem of late type seen almost edge on. It contains H-II regions, and its outer parts show the structure typical for beginning resolution of spiral arms. This is quite different from the appearance of the narrow band of obscuration shown by many galaxies, among them C. Wade's radio source near Virgo A. Even at a much larger distance than the Virgo cluster, NGC 5128 could not be mistaken for such an object. Its appearance is indeed unique, so for some time it did not seem acceptable as an extragalactic object and was considered as a diffuse galactic nebula; spectra established later its extragalactic nature.

Any interpretation of NGC 5128 has to take into account the fact that it consists of two parts. One is the flattened system that has been found by E. M. and G. Burbidge to rotate, as one would expect, around its minor axis. The other is an unresolved mass whose bright center appears spherical but whose outer parts are elongated in the direction normal to the flattened system; a photometric investigation by J. L. Sercic has confirmed this description. Thus, the flattened system rotates around the major axis of the unresolved mass. The interpretation proposed by W. Baade and this writer, that the object consists of two galaxies, avoids having to assume rotation of a flattened subsystem around the major axis of a galaxy and admits tidal distortion as an explanation for the distortion of the flattened system. However, there is no need to assume that the two galaxies are in collision. So many double galaxies have now been identified as radio sources that it is impossible to consider all of them as being in collision. But it is now established that some as yet unexplained process tends to produce strong radio emission in double galaxies.

It is not clear why the complicated structure of the radio source should be easier to understand if NGC 5128 is a single system. If this interpretation is to be adopted, it is necessary to accept the unconvincing picture of the rotation of a galaxy around its major axis and to find an explanation other than the interaction between two galaxies for the distortion of the flattened subsystem.

Cygnus A is quite different from NGC 5128. It is an object of elliptical outline, about 18 by 30 seconds of arc, with two bright, distorted central condensations separated by about two seconds in an area three by five seconds. Cygnus A is not crossed by an absorption lane. The too contrasty positive picture on page 259 of the November issue shows only the two central condensations.

The 200-inch photographs of Cygnus A are difficult to reproduce. The best overall picture is Fig. 11c in the January, 1954, *Astrophysical Journal* [reproduced below], yet even this shows only the brightest inner part of the elliptical object. It is true that, looking at pictures showing only the central condensations of Cygnus A, one might have the impression of some similarity to NGC 5128, but this impression disappears at once if both of them are viewed on the same relative scale. For the SKY AND TELESCOPE reproductions, this equality of scale can be achieved by placing the picture of NGC 5128 on page 260 three times as far away as the one of Cygnus A on page 259.



This photograph of Cygnus A was taken with the 200-inch Hale telescope, filters limiting the spectral region to 5000-6200 angstroms (blue-green to orange). This enlargement is printed as a negative to bring out the halo surrounding the two central condensations. The scale here is about 21 seconds of arc per inch. Mount Wilson and Palomar Observatories photograph.

The interpretation of this object as representing a collision between two galaxies seems the simplest way to explain the presence of two distorted nuclear condensations and of an emission spectrum of unusually high excitation. That the emission lines are single with a width of about 500 kilometers per second does not prove that the space velocity is too small to provide sufficient kinetic energy. It is improbable, although not impossible, that the space motion is nearly at a right angle to the direction of vision. More likely, the conditions in Cygnus A may be similar to those in NGC 1275.

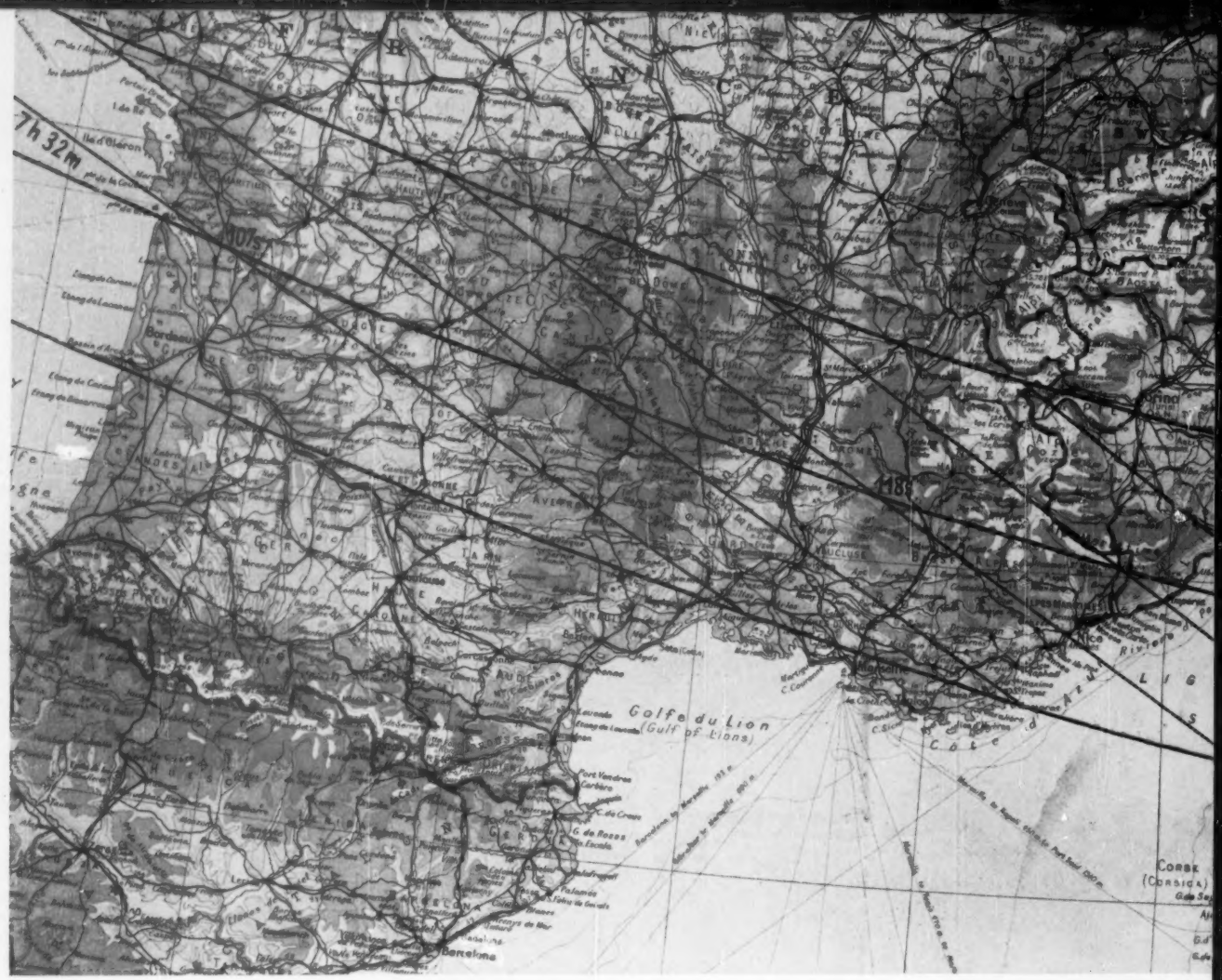
The latter is a double galaxy. It is not true that there are two masses of gas only; an emission line was most suitable to illustrate the duplicity, but the spectra show emissions and absorptions of both galaxies. Their relative radial velocity is 3,000 kilometers per second; many other features of the object suggest that a collision is in progress. In the central parts, not only in the nucleus of one of the galaxies, there are single emission lines with a width of about 1,200 kilometers per second — the much greater width reported by earlier investigators seems to have been spurious. Clearly, the width of the single emission lines in the central parts is no indicator for the relative space velocity of NGC 1275, and a similar situation may prevail in Cygnus A.

The probability of a suitable collision may be vanishingly small, but whether it is too small to permit the interpretation of a source as due to a collision can be decided only if the space density of such sources is known. Actually, Shklovsky underestimates the probability by assuming an absolute magnitude of -21 for each of the two galaxies in Cygnus A. The observational data lead to an absolute magnitude of -20.1 for each stellar system, since half of the light is due to the emission lines. The identification of radio sources has now reached a stage in which the space density of sources of a given strength can be determined (article in press). There is one source of the intrinsic strength of Cygnus A in about 2×10^8 cubic megaparsecs. Within the limits of the part of the universe observable with the 200-inch telescope, there are only about 40 sources of the intrinsic strength of Cygnus A. Rough estimates suggest that a number of this order, vanishingly small compared to the number of clusters of galaxies, is consistent with the vanishingly small probability of observing a suitable collision.

Neither of the arguments thus seems to rule out at this time colliding galaxies as the origin of Cygnus A, although a better interpretation may some day be possible.

R. MINKOWSKI
Washburn Observatory
University of Wisconsin
Madison 6, Wis.

(Letters continued on page 29)



This map showing part of the path of totality at the February 15, 1961, solar eclipse was prepared by M. de Saussure, University of Geneva, Switzerland. The slanting lines are to indicate Universal times of mid-eclipse at one-minute intervals. At some of their intersections with the central line the duration of totality is given in seconds.

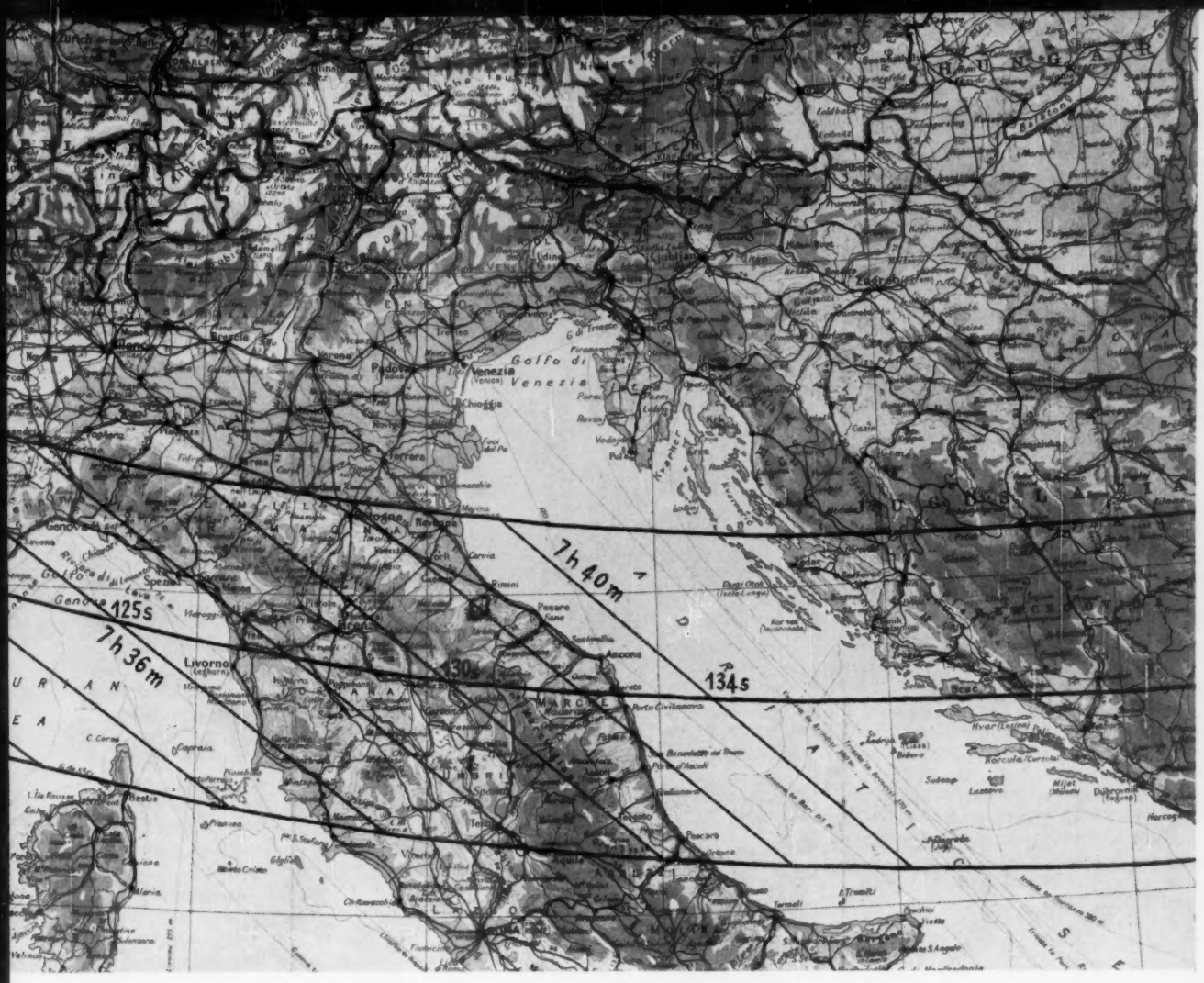
Prospects for Next Month's Eclipse

THIS FEBRUARY 15th a total solar eclipse of unusual interest occurs as the moon's shadow sweeps across the homes of millions of people and the telescopes of some dozen European observatories (SKY AND TELESCOPE, July, 1960, page 16). Many American professional and amateur astronomers are planning to observe the event. In order to decide upon the optimum location for an eclipse station, each observing group must balance observational considerations (the elevation of the sun and the duration of totality) against probable weather conditions.

Scientific groups across Europe have been concerned with this problem and have collected meteorological information from France to Russia. The sun's altitude at total eclipse will be between zero and 28 degrees; central-line totality lasts at most 165 seconds. Probable weather conditions are very poor to good.

The sun rises eclipsed over the Bay of Biscay and the shadow moves across southern France. Over the Riviera, where totality occurs at about 7:34 Universal time, the sun will still have a low altitude, and scientific observations will be difficult. Entering Italy, the path of totality cuts over the extreme southwest corner of the Ligurian Coast into the Gulf of Genoa at Allassio. There at 7:35 UT the sun will be 11 degrees above the horizon, with totality lasting about 122 seconds. On the eastern coast of the gulf, the mid-point of the moon's shadow passes south of Pisa at 7:37 UT, the sun being 12 degrees high. Then the central line passes about 12 miles south of Florence, crosses the Apennines north of Arezzo, and moves on to Loreto, 12 miles south of Ancona on the Adriatic. There at 7:39 UT the sun will be 14 degrees above the horizon and totality will last 133 seconds. By crossing to Italy's east coast, therefore, it is possible to gain about 10 seconds in the duration of totality and three degrees in solar altitude.

East of the Adriatic, the line of central eclipse strikes the Yugoslav coast and continues over Mostar, Yugoslavia, along the Romanian-Bulgarian border, and then through Constantsa on the Black Sea. Maximum duration of totality occurs at about 8:20 UT in the Soviet Union, on the Azov Sea, near Rostov-on-Don, where near local noontime the sun will stand 28 degrees above the southern horizon. The path of totality then sweeps from northwest of the Caspian Sea to northern Siberia, where the eclipsed sun may be observed as it sets.



Brief examination of probable weather conditions along the line of total eclipse narrows the choice of observing sites. E. R. Mustel, of the International Astronomical Union's commission for eclipses, reports that in the U. S. S. R., "the weather conditions for mid-February are extremely unfavourable along the whole path of eclipse. Cloudy weather, frequent fogs and strong winds prevail during this period all over the Crimean peninsula, Rostov and Stalingrad regions. . . . A somewhat better weather can be expected in the Ural Mountains, but at the moment of the eclipse the Sun will be very low over the horizon there."

The British Meteorological Office gives data for the Balkans, where the altitude of the sun will average about 23 degrees. Along the path of totality, from Yugoslavia to the Black Sea, the average cloud cover at any time ranges from 52 to 67 per cent. The average number of completely cloudy days in February is about 15; the number of clear days in the same month is perhaps five. Fog occurs about one-fourth of the time.

On the whole, it does not seem probable that American expeditions will go to the region east of the Adriatic. Although the view of the eclipse would be best in that area, the likelihood of experiencing overcast skies at that time is great.

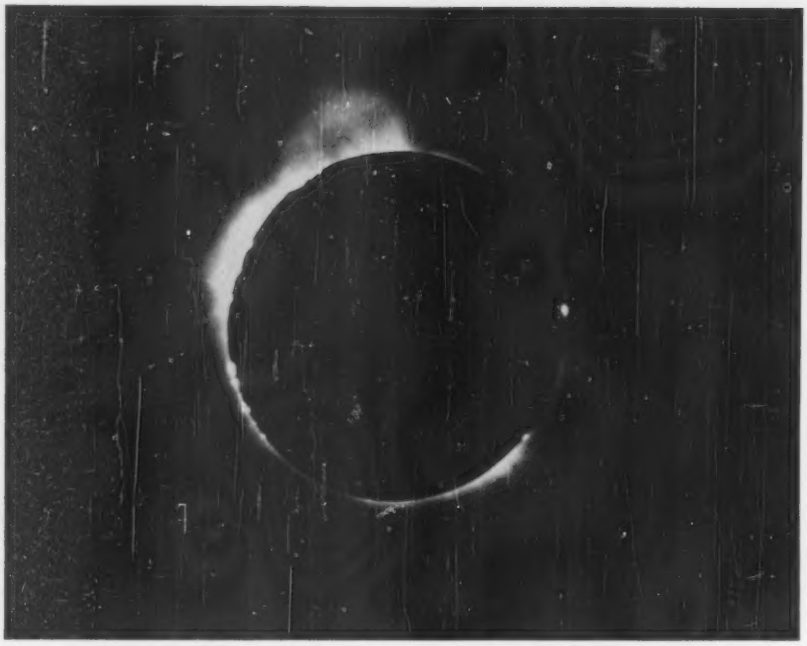
A choice is left between southern France and northern Italy, mapped here by M. de Saussure. In the July-August, 1960, issue of the French Astronomical Society's *l'Astronomie*, the weather possibilities for this area are outlined. For southeastern France, meteorological data for five years (1955-59) have been compiled by the French national weather bureau. In general, clouds over this area cover about one-third to one-half of the sky during the month of February. In the course of a morning, cloudiness tends to increase between 6 and 9 a.m. and then decreases again toward noon. At six o'clock (about an hour before sunrise on eclipse morning), the cloud cover at Orange, in Provence about 70 miles northwest of Marseilles, averaged 45 per cent, and at Nice, 49 per cent.

One should not be misled by the averages, for during the very sunny winter of 1959, both locations experienced at 6 a.m. only 25-per-cent cloudiness, while during 1957 the sky was about 60-per-cent covered. The number of hours of sunlight in February is ordinarily about 20 per cent more at Nice than at the other French stations. Probably the extreme southeast corner of France, just north of Menton on the Italian border, will be the area where many amateurs planning to observe from France may set up camp.

Examination of data from Italy, for the years 1950-55, reveals that the chances of having a clear sky at six o'clock decrease sharply, from about 50-50 at San Remo on the west coast of the Gulf of Genoa to about one in six at Ancona on the Adriatic. The chance of a partially cloudy sky, about one in five in these two cities, reaches a maximum over the Apennines. Also, the probability of a complete overcast doubles, from one-third to two-thirds, between the two extreme stations.

The least wind is usually experienced at Mondovi, north of San Remo, and this, together with the relatively high percentage of clear days, should make northwestern Italy the most favorable location for eclipse observing. It is near this region that the great Italian observatories of Rome, Padua, and Florence are preparing to view the event. However, even the weather records of many years do not permit a reliable prediction for any particular locality to be made many days in advance.

Offers of assistance from some European societies have been made to those ama-



Pierre Bourge, of the Astronomical Society of Normandy, France, secured this photograph of the October 2, 1959, total eclipse from Las Palmas in the Canary Islands. He used a 10-inch f/5 telescope and Kodachrome film.

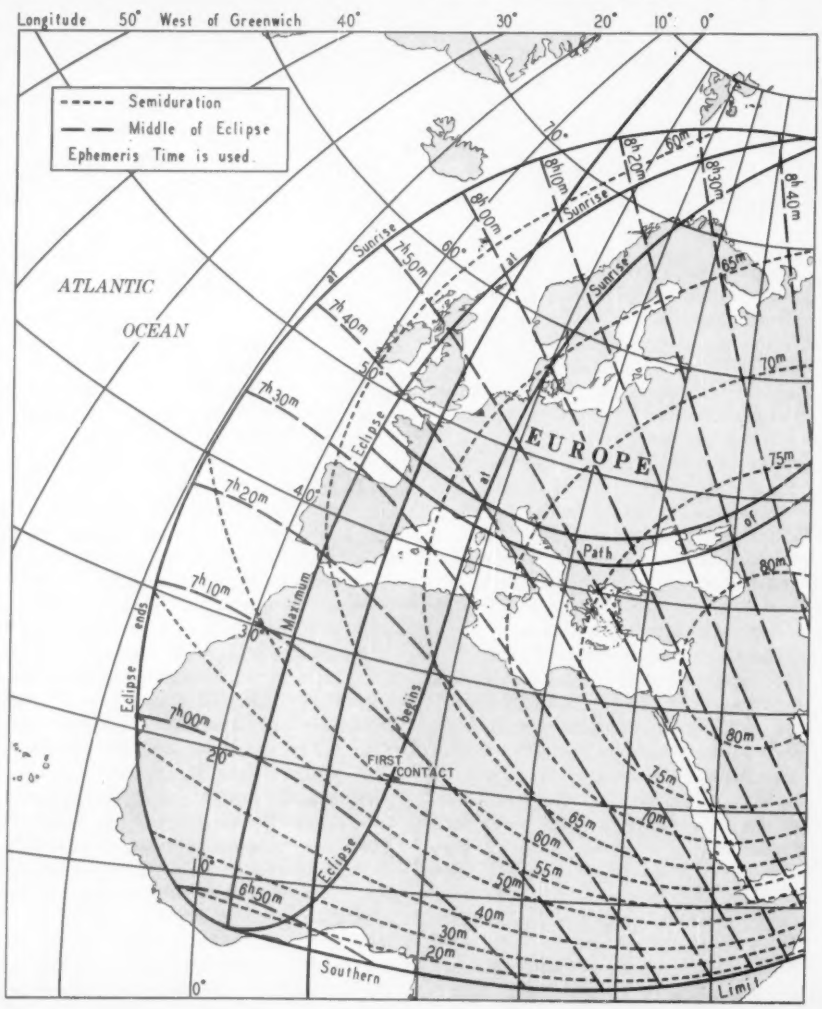
teurs wishing to set up eclipse camps. In addition to the Société Astronomique de la Cote d'Azur (page 325 last month), the Astronomical Society of Croatia is interested in providing locations for society expeditions. Contact should be made with the president, Mladen Hegedusic, Jurisiceva 13, Zagreb, Yugoslavia. The Intourist organization of the U. S. S. R. has also expressed a willingness to help observers going to the Soviet Union.

An international team of five Swiss and Italian amateurs is planning to observe from a base in Genoa, Italy. Some members of the group will attempt to photograph the event from an airplane, as they did during the October 2, 1959, eclipse over the Canary Islands. The photographic equipment, writes Lucca Erizzo, includes a Questar telescope with Hexacon camera and a Leica camera with a 400-mm. telephoto lens.

Among the problems in astronomical photography from an airplane is telescope vibration. In his plans to photograph the eclipse over the Adriatic Sea, J. R. Hereford of the McDonnell Aircraft Corp. hopes to achieve vibration insulation by clamping the telescope at its forward end on a rubber shock-mounted swivel. An added advantage to this forward mounting is that the swivel point is placed near the cabin window, giving maximum flexibility in aiming. Photographing through the plexiglass canopy of an aircraft introduces chromatic aberration and some distortion of the image. Mr. Hereford found in 1959 that least distortion occurs when the instruments are removed as far as possible from the canopy material.

On the morning of the eclipse, the two members of the Swiss-Italian expedition at Genoa who will make ground observations will be informed by telephone from Albenga (to the west), Passo dei Biovi (north) and Portofino (east) as to where the sky is clear. They will then drive to the clearest area.

Dr. J. W. Evans, director of the Sacramento Peak Observatory, writes that, because of the dubious weather outlook, there will be no expedition from Sunspot, New Mexico, to Europe. He adds, "We think we will do better to save our energy and resources for an expedition in 1963. This is a July eclipse that goes clear across Canada, and we certainly ought to be able to find some place along the path with a reasonable chance of good weather."



The western half of the eclipse chart in the "American Ephemeris" is reproduced here to show the extent of partial eclipse in Europe and Africa. In Paris the sun will be 95.7 per cent covered by the moon. At Strasbourg and Algiers, the magnitude will be 95.0 and 87.2 per cent, respectively. East of this area, partial eclipse occurs over much of western Asia, including northwestern India.

NEWS NOTES

COLOR-MAGNITUDE DIAGRAM FOR REMOTE RADIO SOURCES

The radio energy of 18 extragalactic sources has been measured at two wave lengths, 21.4 and 68.2 centimeters, by David S. Heeschen with the 85-foot Tatel radio telescope of the National Radio Astronomy Observatory. By plotting his results in a "color-magnitude" diagram, he has found a possible correlation between the intrinsic intensity of the strongest sources and the steepness of their spectra at radio wave lengths.

The apparent radio magnitude (m) of a cosmic source at a particular wave length is expressed by the formula:

$$m = -53.4 - 2.5 \log S,$$

where S is the measured flux density at that wave length. For his observations, Dr. Heeschen measured S against the flux density of Cassiopeia A, a standard strong radio source, whose radio magnitude was already known.

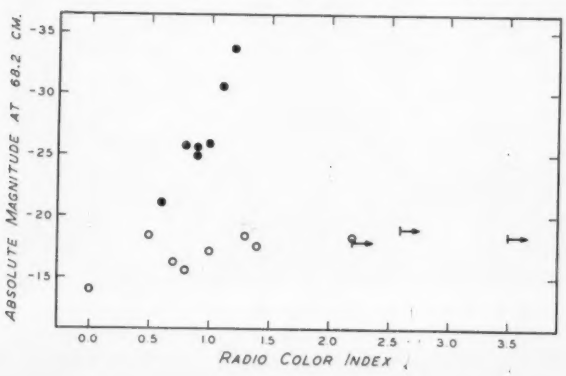
For a radio-frequency "color index," the difference between an object's apparent magnitudes at 21.4 and 68.2 centimeters was taken, its value being positive if the source was brighter at the longer wave length. To obtain absolute radio magnitudes, the presently estimated distance of each extragalactic source was applied to the apparent radio magnitude.

The observed sources fall into two groups, indicated in the diagram by open circles representing "normal" galaxies and filled circles for "peculiar" galaxies. The designation normal or peculiar is based largely on the intensity of radio emission and on the visual appearance of the galaxy. The seven peculiar ones are all more intense emitters than any of the normal systems. They also show peculiarities in visual appearance, or in optical spectra, or both. But at least one of the normal galaxies is spectrally unusual without having the strong radio emission of the peculiar group.

Dr. Heeschen cautions against premature inferences from the diagram. First, there may be an observational selection effect because of the limited sensitivity of the radio telescope. Second, some of the sources in this study are not surely identified with the associated optical objects whose distances have been used. In general, the uncertainty in absolute magnitude at 68.2 centimeters is estimated to be about one magnitude for the 18 observed objects, while the color index may be uncertain by half a magnitude for most of the normal galaxies, and perhaps two or three times this value for one or two of them. For the peculiar galaxies, the color index is far more precise, from less than ± 0.05 magnitude in the best case to about ± 0.2 in the poorest.

The normal galaxies seem to form a more-or-less homogeneous group, although their range in color index is rather unexpected. This may be accounted for in part by observational uncertainties. More data are needed before it can be deduced that for the peculiar galaxies there is a correlation between radio magnitude and color index. Dr. Heeschen is continuing this work at a third wave length, 10 centimeters.

Details of this study are to be found in the *Publications* of the Astronomical Society of the Pacific.



A color-magnitude diagram for 18 extragalactic radio sources. The color index is the difference in radio magnitude taken at 21.4 and 68.2 centimeters wave length. Three "normal" galaxies are plotted as lines with arrows to indicate lower limits to their color indexes. National Radio Astronomy Observatory diagram.

C. E. KENNETH MEES DIES

A world-renowned authority on scientific photography, C. E. Kenneth Mees, passed away last August 15th in Honolulu, Hawaii. He was 78 years old.

Born and educated in England, Dr. Mees joined the staff of Eastman Kodak Co. in 1912 at its research laboratories. Under his direction, special plates for fast celestial photography were invented, a major boon to modern astronomy.

He received many awards for his work, including the Henry Draper medal of the National Academy of Sciences in 1937. Dr. Mees was a patron of the American Astronomical Society, a fellow of the Royal Society, and a member of the Royal Astronomical Society.

Upon his retirement to Hawaii, he took an active interest in the development of the Hawaiian Astronomical Society. Shortly before his death, he made a generous gift toward the completion of the planetarium and observatory being built by the Bishop Museum. A history of his research in photography, *From Dry Plates to Ektachrome Films,* had just been completed when he died.

OPTICAL SOCIETY MEETING

The 1961 spring meeting of the Optical Society of America will be held in Pittsburgh, Pennsylvania, March 2-4. A symposium on "New Frontiers in Optics and Spectroscopy" is scheduled for Thursday morning, March 2nd, at the Penn-Sheraton Hotel. The speakers include A. B. Meinel, "New Frontiers of Astronomical Optics"; Charles H. Townes, "Optical and Infrared Masers"; and J. R. McNally, Jr., "Spectroscopic Studies in the Thermonuclear Field at the Oak Ridge National Laboratory."

Invited papers also will cover optics in Japan, workshop practice, and modern methods of lens design. Further information is available from Dr. Mary E. Warga, OSA Executive Office, 1155 16th St. N.W., Washington 6, D. C.

IN THE CURRENT JOURNALS

THE AGE OF THE ELEMENTS IN THE SOLAR SYSTEM, by John H. Reynolds, *Scientific American,* November, 1960. "An age of 4.6 billion years is now generally accepted for both meteorites and the crust of the earth. All evidence indicates that the stable, cold objects in the solar system took their present form at about that time."

RADIATION ENVIRONMENT IN SPACE, by Homer E. Newell and John E. Naugle, *Science,* November 18, 1960. "By 1967, plans and vehicle construction for the circumlunar mission will be well under way. Therefore, the shielding concept for this mission must be solved on the basis of the data presently available."

A NEW INTERPRETATION OF MARTIAN PHENOMENA, by C. C. Kiess, S. Karrer, and H. K. Kiess, *Publications* of the Astronomical Society of the Pacific, Vol. 72, No. 427, 1960. "If the above explanation of the Martian atmosphere is correct, then it will be necessary to abandon all ideas of Mars as an abode of life. For it is well known that nitrogen peroxide in small amounts is noxious to plants, and in larger amounts to animals. . . . Mars may be considered as the locale . . . of landscapes quite unlike anything existing on the earth."

THE RECOVERY OF COSMIC-RAY EMULSIONS FROM ROCKET AND SPACE PROBES, by Herman Yagoda, *Physics Today,* October, 1960. "To identify and to measure the relative proportions of the diverse components present in the primary cosmic-ray beam arriving from space the instrumentation must be sent above the atmosphere."

GETTING ACQUAINTED WITH ASTRONOMY

THE PLANETS — MARS – II

AT FIRST THOUGHT, it might seem that nearly a century's study of Mars with powerful telescopes has left little uncharted on the red planet, but this is far from true. Many novel and useful observations are still possible with larger amateur instruments, skillfully used.

One reason for the incompleteness of past records is that Mars' distance varies greatly, and for much of the time it is too remote for satisfactory observations to be made. Only near the times of opposition, say for three months out of 26, can detailed work be done. Even when the planet comes as close as possible to the earth, as it did in August, 1924, its reddish disk, dappled with darker markings, appears only as large as a dime seen from 160 yards.

Another reason is that during a single view of Mars only a relatively small part of its surface can be well seen, for near the edge of the disk foreshortening and veiling by the Martian atmosphere are hindrances. Moreover, Mars' rotation period is only about 37 minutes longer than the earth's, necessitating repeated observations over five weeks for an examination of all Martian longitudes.

Thus we can obtain only a piecemeal patrol of a planetary surface that is constantly changing. There are pronounced seasonal fluctuations in the polar caps and the dark markings, as mentioned in the first part of this article (November, 1960, page 277). The finer details often vary greatly in conspicuousness from one opposition to the next. Though the main Martian features persist from decade to decade, there are large-scale alterations that invalidate the older maps, such as the transformation in Solis Lacus since G. V. Schiaparelli's observations in 1877. In the mid-1950's a new dark area, larger than Alaska, appeared northeast of Syrtis Major (August, 1956, page 442).

Other changes, rapid and transitory, occur in the Martian atmosphere. In recent years, much attention has been given to the drift of clouds, as they can give valuable information about Mars' winds and pattern of atmospheric circulation. The rare *blue clearings*, during which the planet's atmosphere temporarily ceases to be opaque to blue light, remain a mystery. Sometimes a veil of yellow cloud effaces detail over much of the surface, as in 1956. There is no question that Mars continues to offer much to its devotees.

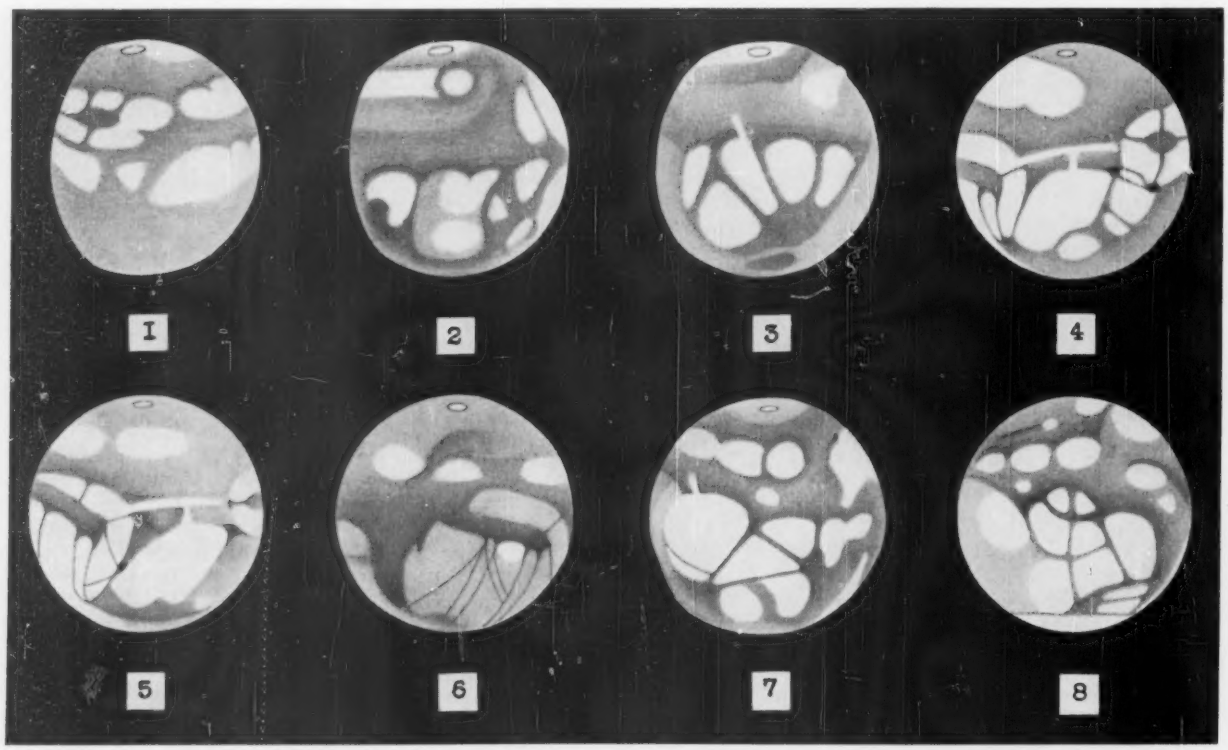
Although experienced observers under favorable circumstances can obtain pleasing views of Mars in 4- and 6-inch telescopes, larger instruments are much better. An 8- to 12-inch reflector is very suitable for systematic work. Increased aperture gives improved resolution and, even more important, it enhances the faint contrasts between the dusky markings and the ocher deserts.

Even with an adequate instrument, an amateur's first view is apt to be disappointing, for the little red disk looks nearly featureless, with only a hint of some darker patches. But if he perseveres, and looks night after night, his eye gradually educates itself to detect more and more. On recommencing work at another opposition, some Martian observers of many years experience have to retrain their eyes in this way.

The importance of changes in seeing conditions will soon be learned by a new Mars observer. On most nights a prolonged watch is necessary, for from time to time, perhaps at intervals of several minutes, the air may suddenly grow steady, and for a few seconds the fine details become clearly visible.

DRAWINGS

A careful pencil drawing is a convenient, concise way of making a permanent record of how Mars appeared on a particular occasion. Sets of drawings are useful for studying seasonal changes, and for measuring areographic longitudes and latitudes of features. An ample scale should be chosen. The British Astronomical Association recommends three milli-



Clark C. McClelland made these eight drawings of Mars in the fall of 1958 with Allegheny Observatory's 13-inch refractor. Note the small south polar cap near the top of the disk, except in picture 8. Contrasts and sharpness of outline have been exaggerated to facilitate reproduction. Information for each drawing is given in the table on the next page.

meters per second of arc, corresponding to disk diameters of 1.8 inches on January 1, 1961; 1.5 on February 1st; and 1.1 on March 1st.

To be of value, each drawing must be labeled with the date, time, instrument, magnification, and quality of the seeing. The depiction will not be independent evidence unless care is taken to avoid bias, which would result from consulting Mars maps or other drawings beforehand.

Mars turns rapidly on its axis, and in the half hour that may be needed to prepare a finished sketch a considerable displacement of its surface features will take place. To avoid distortions, W. H. Pickering's procedure can be followed. Before starting on a drawing, spend some minutes looking at the planet to become familiar with its main features. Then sketch the major outlines, noting the time. Afterward, insert smaller markings in the proper places with respect to these outlines. This method is particularly desirable if the drawing is to be used later for measurements.

An interesting project is to trace the changes in size of the Martian polar caps, from a series of drawings extending over as many months as possible.

Examples of Mars drawings may be found in many recent books and in nearly every issue of the *Strolling Astronomer*. The eight drawings shown here were made by Clark C. McClelland with the 13-inch Fitz-Clark refractor of Allegheny Observatory in Pittsburgh. The table gives the date in 1958, the Universal time, the seeing on a scale of 0 to 10, Mars' apparent diameter in seconds of arc, the areographic longitude of the meridian that was central on the disk at the time of observation, and the filter used.

No.	*Date*	*UT*	*Seeing*	*Size*	*Long.*	*Wratten*
1	Sept. 14	5:00	7-8	13″.9	102°	6 Amber
2	Oct. 6	3:20	5-6	16″.4	233°	6 Amber
3	Oct. 11	3:57	5-6	17″.1	196°	25 Red
4	Oct. 30	4:40	5-6	18″.9	36°	25 Red
5	Oct. 31	3:50	6-7	19″.0	15°	25 Red
6	Nov. 5	3:22	7-8	19″.2	324°	25 Red
7	Nov. 14	2:40	6-7	19″.1	234°	None
8	Nov. 18	2:05	7-8	18″.9	191°	None

Transits

An important but sometimes overlooked kind of visual observation is timing central meridian transits of Martian features. For example, suppose that the small, very black marking Juventae Fons is seen a little to the right of the center of the disk. The rotation of Mars will carry it leftward, and the desired observation consists of noting the time when this spot passes the imaginary line through the centers of the disk and the polar cap. Such transits can be timed with an uncertainty of only a few minutes.

The *American Ephemeris* lists at one-day intervals the longitude of the central meridian of Mars, an angle that increases by about 351 degrees daily. The value for the observed time of a transit is found by interpolation; it is numerically equal to the Martian longitude of the marking. The transit observations should be confined to the two or three weeks preceding or following the date of opposition, for at other times the phase of Mars can introduce large errors.

Longitude observations of any well-defined surface features are very desirable, as they provide the basis for determining the rotation period of Mars. Information about this problem can be found in the *Astronomical Journal* for 1953, Vol. 58, page 145.

Intensity Estimates

Several different numerical scales have been used by independent observing groups to describe quantitatively the brightnesses of different areas on the Martian surface. The most useful of these is G. de Vaucouleurs', described in detail in his book, *Physics of the Planet Mars*, pages 314 to 325, 1954. He uses three standards: T = 0, the surface brightness of the polar cap when it is largest; T = 2, the average for light areas (continents) near the center of the disk; and T = 10, the brightness of the sky background. In estimating a Martian feature, its brightness is interpolated between two of these standards. Dr. de Vaucouleurs explains in detail the precautions that make this method yield accurate photometric results.

Clouds

In the dry, desert atmosphere of Mars, clouds are uncommon, and any one that appears deserves intensive observation. White clouds, believed due to water droplets, are low-level phenomena, while yellow ones of dust may be as high as 20 miles above the planet's surface. Occasionally a cloud is noted as a bright projection at the terminator (where it is Martian sunrise or sunset), and if the distance the cloud extends into the night side of Mars is noted, it is possible to calculate the altitude it must have still to catch direct sunlight.

Of particular interest are Martian clouds persisting over several nights. Plotting successive positions on a map will indicate the direction and speed of the wind — a valuable addition to our limited information about the planet's pattern of atmospheric circulation.

Color filters are helpful in recognizing and classifying Martian clouds. Charles F. Capen, Jr., describes their use in Sky and Telescope, August, 1958, page 517. Filters aid photography, too, but taking useful pictures of Mars is a specialized art requiring a large telescope and much photographic skill.

Amateurs who plan to devote many telescope hours to the red planet will gain much by joining an organization of like-minded observers. The Mars recorder for the Association of Lunar and Planetary Observers is Ernst E. Both, Buffalo Museum of Science, Buffalo 11, N. Y. Another active group is the Mars section of the British Astronomical Association. The address of its director, E. H. Collinson, is Culpho End, Culpho, Ipswich, Suffolk, England.

LETTERS

(Continued from page 23)

Sir:

On Saturday, September 17, 1960, I was fortunate to observe a very rare halo complex [see also page 14]. Very thin cloud overspread the sky, and at 11:45 a.m. Eastern standard time I noted a bright halo, slightly colored, above the hazy sun. The usual 22-degree halo was visible, but faint. Instead, an elliptical or circumscribed halo around the 22-degree ring was extremely bright and colorful.

The rarest phenomenon of that day was the completeness of the horizontal or parhelic circle; though faint, it extended entirely around the sky at the altitude of the sun. Opposite the sun on this circle was an anthelion, with a St. Andrew's cross visible. Yet near the sun itself there were no mock suns or sundogs.

HERBERT A. LUFT
69-11 229th St.
Oakland Gardens 64, N. Y.

Sir:

Recently I have found a simple formula that gives surprisingly good approximations to the mean velocities of the planets in their orbits around the sun. Let the planets, beginning with Pluto, be numbered $n = 1, 2$, and so on, with $n = 6$ for the asteroids. Then the predicted velocity in miles per second is given by $V' = 0.1\ (3n^2 - 4n + 29)$. In the table, the predictions are compared with the actual velocities, V.

n	*Planet*	*V′*	*V*	*Error*
1	Pluto	2.8	2.9	−0.1
2	Neptune	3.3	3.4	−0.1
3	Uranus	4.4	4.2	+0.2
4	Saturn	6.1	6.0	+0.1
5	Jupiter	8.4	8.1	+0.3
6	———	11.3	—	—
7	Mars	14.8	15.0	−0.2
8	Earth	18.9	18.5	+0.4
9	Venus	23.6	21.8	+1.8
10	Mercury	28.9	29.8	−0.9

Except for the case of Venus, the errors of the prediction formula are rather small.

JOHN R. HALL
4556 Columbia Ave.
Lincolnwood 46, Ill.

Amateur Astronomers

California Amateurs Study at New Observatory

SOUTHERN CALIFORNIA is well known for its giant telescopes, amateur as well as professional. Probably the Los Angeles Astronomical Society has more telescopes of 16-inch aperture and larger than any other group in the United States. Most recently, several advanced amateurs in this area, including the writer, have been invited to use the fine facilities of Josef P. Biela in Anaheim.

His 16-inch Cassegrainian is on the rooftop above his study, the plywood dome and shutter being electrically operated. The observatory is reached by a steep staircase and trap door. The 16-inch reflector has a 4½-inch declination axis and a conical polar axis of similar size. Its weight drive is governor regulated, with slow-motion controls handy at the eyepiece.

There are three guide telescopes, of 6-, 4-, and 3-inch aperture, all f/15, while the main instrument is f/20, its effective focal length being 320 inches. Some 25 eyepieces provide an ample range of magnifications, up to 2,000x being possible. We amateur observers have the use of star diagonals, erecting prisms, eyepiece turrets, and several cameras. There is a 3¼-by-4 double-slide plateholder and focal-plane shutter.

Present plans call for additional accessories to permit astronomical closed-circuit television experiments, photoelectric observations of the moon and planets, and magnitude work on flare stars and other peculiar variables. The writer has already made some drawings of Saturn, recovering a minute division in ring A that was previously seen by Thomas R. Cave, Jr., in 1957.

We believe that other amateurs in this country would benefit if similar well-equipped private observatories were made available to them.

LEIF J. ROBINSON
1411 Amapola Ave.
Torrance, Calif.

CLARENCE E. JOHNSON DIES

Junior astronomers lost one of their most ardent boosters with the passing of Clarence E. Johnson, of Schenectady, New York, on October 24th. The 64-year-old amateur was recognized for his work when the Astronomical League gave him its annual award in 1958.

Long a post office employee, Mr. Johnson had served as president of the Schenectady Astronomy Club and as chairman of the AL's Northeast region. He was also junior activities chairman for the league for many years.

Members of the Schenectady society were pallbearers at Mr. Johnson's funeral. The club has named its observatory in his honor.

THIS MONTH'S PROGRAMS

Cleveland, Ohio: Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. January 20, Dr. John P. Hagen, National Aeronautics and Space Administration, "The Astronomical and Geophysical Benefits from the Space Program."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. January 4, Dr. Dorrit Hoffleit, Maria Mitchell Observatory, "Astronomy 100 Years Ago."

Philadelphia, Pa.: Rittenhouse Astronomical Society, 8 p.m., Franklin Institute. January 13, John E. Gaustad, Princeton University Observatory, "The Life History of a Star."

Plainfield, N. J.: Amateur Astronomers, Inc., of Union County, 8 p.m., Stillman School. January 20, Dr. Robert Danielson, Princeton University Observatory, "Structure of Sunspots."

A PLANETARIUM PROJECT

After reading about the Korkosz projector at the Hayden Planetarium in Boston several years ago, I decided to purchase a Spitz, Jr., projector for my own entertainment. But I became dissatisfied with the small number of stars it produced, so I made punctures for about 250 fainter ones.

In order to reproduce the Milky Way, I disassembled the projection sphere, then applied film cement with cotton to remove the paint on the globe along the path of the Milky Way. The result is very realistic. Tinted cellophane placed over the appropriate openings colors stars of the 1st- and 2nd-magnitudes, while six old camera lenses fastened to the inside of the sphere make the brightest stars smaller and more brilliant.

I have also developed auxiliary projectors for producing such effects as clouds, snow, lightning, meteor showers, comets, and the moon. I would like to hear from other amateurs who have similar undertakings.

DANIEL ZIRPOLI
39 John Ryle Ave.
Haledon 2, N. J.

TWO NEW SOCIETIES

Twelve amateurs have organized the Greater Lawrence Astronomical Society. Interested persons should communicate with the president, Emil DesRosiers, 32 Oakland Ave., Methuen, Mass.

Meetings of the Camden Astronomy Club are held on the third Tuesday of the month at the Hotel Camden. The group has nine adult and five junior members. Its president is Bill Shelton, Chamber of Commerce, Camden, Ark.

+++ Amateur Briefs +++

The Ohio Valley Amateur Astronomers of Steubenville, Ohio, have changed their meeting night to the third Friday of the month to accommodate those members who like to sleep late after their extended get-togethers.

Most of the 48 members in the Skywatchers Astronomy Club at Hampton, Virginia, are engineers or technicians from the National Aeronautics and Space Administration division at Langley Field. The club, however, is also open to the public.

Trading-stamp books are being donated by members of the Columbus, Ohio, Astronomical Society, in order to acquire a slide projector for the club.

Up to 20 mirrors may be ground simultaneously in a newly renovated optical shop at the observatory of the Cincinnati, Ohio, Astronomical Association.

Last fall, during the first public star party ever held in West Springfield, Massachusetts, most of the 1,300 visitors had their initial look at the heavens through a telescope. The sponsor was the junior group of the Springfield Stars Club, which set up 20 instruments for the event.

Although sponsored for workers at the Argonne National Laboratory, the Argonne Astronomy Club in Illinois has about 40 nonemployees among its 70 members.

The Academy of Science and Art of Pittsburgh, Pennsylvania, has granted $4,525 to the Amateur Astronomers Association, $500 of which is for operating its Moonwatch station. The remainder will be used for the society's new advanced optics workshop at Allegheny Observatory, including the purchase of a six-spindle power-driven grinding and polishing workbench and miscellaneous equipment.

This is the 29th year for the Astronomical Society of Rutherford, New Jersey, and the 25th for the Amateur Astronomers of the Franklin Institute in Philadelphia, Pennsylvania. Happy birthdays!

Several members of the New Haven Astronomical Society are giving lectures at the new planetarium of Southern Connecticut State College.

H. M. C.

PITTSBURGH AMATEUR DIES

William M. Soukop, a long-time member of the Amateur Astronomers Association of Pittsburgh, Pennsylvania, passed away last November 12th, just after he had attended the society's monthly meeting at the Buhl Planetarium.

A master machinist until his retirement in 1957, the 69-year-old amateur was frequently called upon to repair parts for Buhl instruments, as well as equipment at the Allegheny Observatory. He also assisted many telescope makers in their projects.

Sam Houston College's vibration-free Tinsley telescope

Sam Houston State Teachers College, Huntsville, Texas, needed a telescope primarily for visual and photographic instruction of undergraduate astronomy classes. ☐ A custom-made Tinsley telescope was chosen for two simple reasons: 1) there is no more responsive, reliable telescope made; 2) its massive size and rigidity assure crisp, sharp images—in spite of the fact that it is housed in a rooftop observatory on a busy science building. ☐ When the Sam Houston 16″ Newtonian-Cassegrain reflector is set properly, it remains accurately set. ☐ Large, pre-loaded tapered cone bearings on both axes provide effortless control of the instrument. It is powerful, too. Total effective focal length is 256 inches. ☐ There is no limit to the photographic research Sam Houston students can perform with this telescope. Its versatile Baker Photographic Corrector permits photography of a seven-degree field. ☐ The Sam Houston telescope—like all custom instruments from Tinsley—was designed to meet the client's special needs. If you are faced with a problem such as rooftop mounting, Tinsley can help you solve it. Please address your inquiries to Department C. Tinsley Laboratories, Inc., 2526 Grove Street, Berkeley, Calif.

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Graphic Time Table of the Heavens — 1961

ON THE FOLLOWING pages is a chart that is a condensed and simple almanac, giving the rising and setting times of the sun, moon, and brighter planets, and much other useful astronomical information. This Graphic Time Table is published annually by the Maryland Academy of Sciences, through whose courtesy it is reproduced here for the 20th year. Separate copies may be obtained from the Maryland Academy of Sciences, 400 Cathedral St., Baltimore 1, Md., for 35¢ each; discount on quantity orders. Large wall charts, 40 by 27 inches, may be ordered for $1.25 folded, $1.50 rolled.

How To Use the Graphic Time Table

Across the top and bottom of the chart are marked the hours from 4 p.m. to 8 a.m.; the days of the year run down the chart. Thus any event, such as a particular sunset, can be read by following the horizontal line for the date to where it intersects the curve marking the event, in this case the sunset curve.

In this way the Graphic Time Table shows the rising and setting times of the sun and moon and the planets Mercury, Venus, Mars, Jupiter, and Saturn; the duration of twilight; and the times when certain stars and other interesting objects transit, that is, cross the meridian. The moon's phases are also indicated.

Small numbers at the left give the Julian day number. These numbers are a consecutive count of the days, beginning in 4713 B.C., so January 1, 1961, is JD 2,437,301. Julian days offer a simple way to find the interval between two dates by a single subtraction, and they are widely used by astronomers, particularly in variable star work. The Julian day starts at Greenwich noon, or 6 a.m., Central standard time.

Along the midnight line are Roman numerals that indicate the sidereal time at midnight, in other words, the right ascension of a star then at the meridian on the date in question. Running along the midnight line and crossing it is the curve for the equation of time, which shows how much the sun is fast if the curve is to the left of the line, and how much the sun is slow if the curve is to the right. When the sun is fast, it arrives at the meridian before 12 o'clock noon, by the amount shown between the curve and the midnight line.

Small black circles show moonset for the first half of each lunar month, and small open circles moonrise from full to new moon, for longitude 90° west and latitude 40° north. At 75° west longitude the moon will rise about two minutes earlier than these times; at longitude 120° west, about four minutes later. Also plotted for the moon each day are little marks or "ticks," placed at the corresponding times for moonrise and moonset at the earth's equator; each tick has a horizontal bar pointing toward the time at 40° north, where the open or black moon circle is located. These marks aid interpolation for latitudes intermediate between the equator and 40° north, and may be used for cautious extrapolation to higher latitudes.

Every curve for the rising or setting of the planets has a "ghost" counterpart to show the planet's rising or setting at the equator. These curves are indicated by the appropriate planet symbols and the letter R for rises and S for sets. For example, the equatorial curve for "Mercury sets" starts in the upper left part of the chart and is labeled below the January 12-13 line in the 6:30 to 7:00 p.m. section.

The scale at the right is for finding rising or setting times of other objects. Set dividers, or a strip of paper, from the index at the center of the scale to the object's declination, north or south, and in the direction desired for either rising or setting. Measure this same distance along the midnight line of the chart, beginning at the object's right ascension on the scale marked by the Roman numerals. Should this end point fall outside the chart, add to or subtract from the right ascension 12 hours and reset the dividers, using the end of the scale rather than the center index. Through the point established, draw a line parallel to the "Transit — First Point of Aries" line on the chart. This will show the time of the rising or setting of the object at latitude 40° north.

The Events of a Single Night

As an example, consider the night of January 5-6 by following the horizontal line for that date across the chart from left to right. The Julian day number is 2,437,305. As read from the chart, Mercury sets at 4:40 p.m., eight minutes before sunset, and thus will be invisible. The vernal equinox ("First Point of Aries") transits at 4:59 — marking 0^h local sidereal time. Evening twilight ends at 6:24. The next event is the upper culmination of Polaris at 6:55; it is then due north and directly above the pole. The open circle at 8:31 marks the rising of the moon, which is four days past full. Venus sets at 8:34, and nine minutes later the Pleiades (M45) cross the meridian; other transits are the Great Nebula in Orion at 10:31, Mars at 11:19, and Sirius at 11:41. The sidereal time at midnight will be approximately 7:01, and the line for the equation of time shows that the apparent sun is five minutes slow. Morning twilight begins at 5:43 a.m., Polaris has its lower culmination (being directly below the pole) at 6:53, Mars sets at 7:06, and Jupiter rises 13 minutes later. Sunrise is at 7:21, with Mercury rising 10 minutes later and Saturn at 7:37. The last few events will, of course, not be visible to the unaided eye because of daylight.

How To Correct for Your Position

As in all almanacs, the times of rising and setting of the sun, moon, and planets are strictly correct for only one point on the earth's surface — for this chart, latitude 40° north and longitude 90° west — and the standard time given on the chart is for this point only.

For any other locality, the chart shows local time, which must be converted to standard (clock) time for that place. This conversion depends upon the distance of the observer east or west of his standard-time meridian, the latter being an even multiple of 15 degrees: 75°, 90°, 105°, 120°, 150°, and so forth, west longitude for the United States. The conversion is equal to four minutes of time for every degree of longitude between the observer and the nearest standard-time meridian. It is plus if the observer is west, minus if east of the standard meridian.

In the following table, these corrections are given in minutes of time for 32 locations in the United States.

Anchorage	−1	Los Angeles	−7
Atlanta	+38	Memphis	0
Bismarck	+43	Miami	+21
Boise	+45	Minneapolis	+13
Boston	−16	New Orleans	0
Chicago	−10	New York	−4
Cincinnati	+38	Pittsburgh	+20
Dallas	+27	Rochester	+10
Denver	0	St. Louis	+1
Detroit	+32	Salt Lake City	+28
Durham	+16	San Francisco	+10
El Paso	+6	Santa Fe	+4
Helena	+28	Seattle	+10
Honolulu	+31	Tucson	+24
Houston	+21	Tulsa	+24
Kansas City	+18	Washington	+8

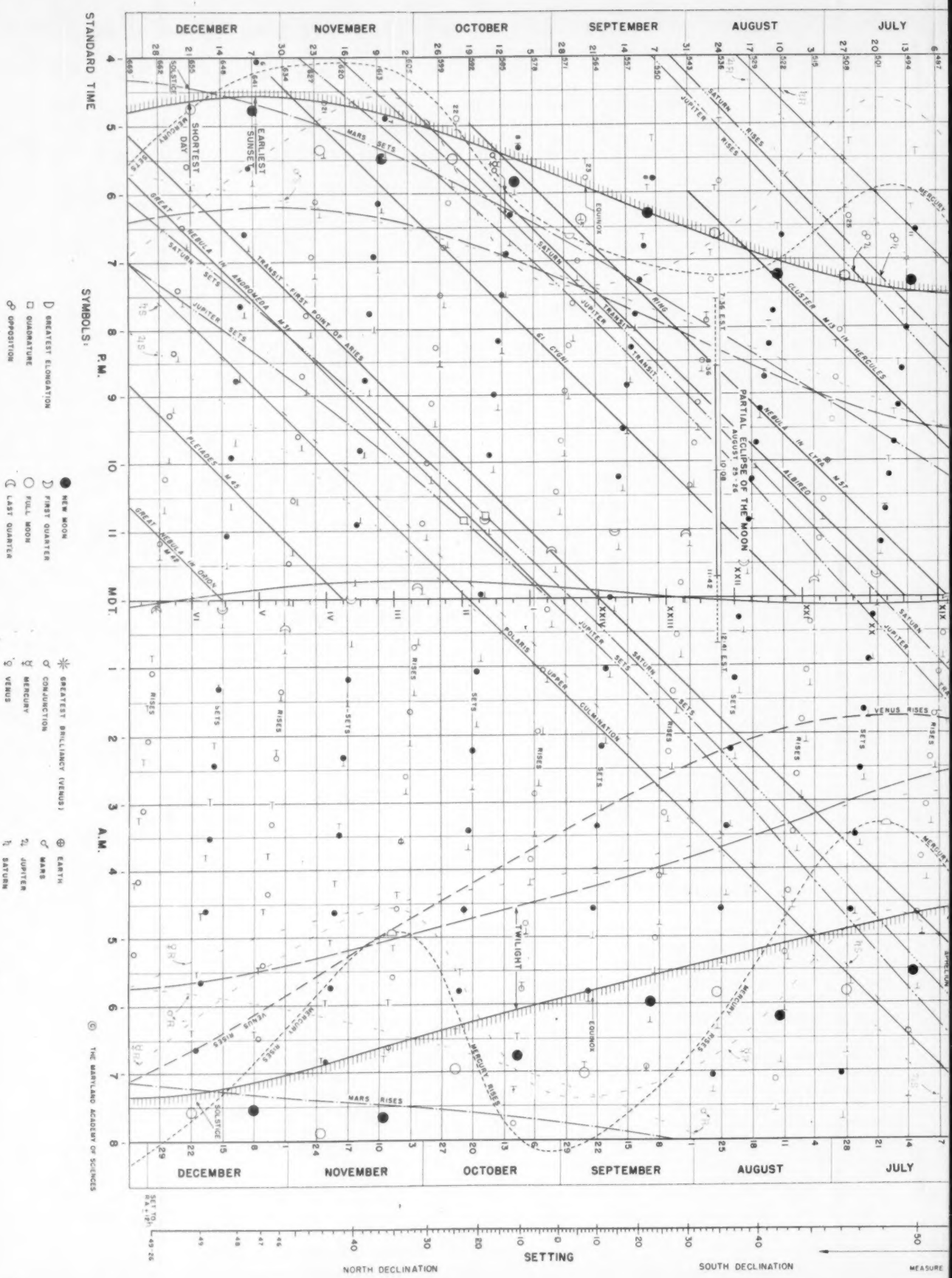
OBJECT GICLAS

A highly unusual asteroid was discovered by Henry L. Giclas on October 22, 1960, at Lowell Observatory in Arizona, while trying to locate a supposed new comet.

The German amateur W. Malsch had taken photographs on October 13th and 14th showing images apparently of an 8th-magnitude comet in Aries. This object has not been satisfactorily confirmed, and its existence is doubtful. Mr. Giclas made a photographic search on the 22nd and 27th with the 13-inch Lowell refractor, finding no comet within several degrees of the expected position, though his plates showed stars as faint as magnitude 16.

But on these same pictures, he noted a 12th-magnitude minor planet, moving eastward at the unusually rapid rate of nearly two degrees per day. During the next month, many additional observations of this fleet object were secured by Mr. Giclas, Elizabeth Roemer at the U. S. Naval Observatory's Arizona station, and G. Van Biesbroeck of Yerkes Observatory.

The exceptional nature of the orbit is shown by calculations of B. G. Marsden at Yale University Observatory. Object Giclas moves around the sun in an ellipse of high eccentricity (0.53), with a period of 3.35 years. When passing nearest the sun, it is only about five million miles outside the earth's orbit; this happened in late September. Object Giclas is only about two miles in diameter, and hence an extremely faint body except when it is in the earth's vicinity. Its distance from both sun and earth is now increasing rapidly, and by the beginning of April the Giclas asteroid will be only 20th magnitude, according to Mr. Marsden's ephemeris in Harvard *Announcement Card* 1515.


DECEMBER
NOVEMBER
OCTOBER
SEPTEMBER
AUGUST
JULY
STANDARD TIME
P.M.
MDT.
A.M.
SHORTEST DAY
EARLIEST SUNSET
SOLSTICE
EQUINOX
PERIHELION
APHELION
MARS SETS
MARS RISES
SATURN SETS
SATURN RISES
JUPITER SETS
JUPITER RISES
TRANSIT
RING
GREAT NEBULA IN ANDROMEDA M31
TRANSIT FIRST POINT OF ARIES
61 CYGNI
PLEIADES M45
GREAT NEBULA IN ORION M42
CLUSTER M13 IN HERCULES
NEBULA IN LYRA M57
ALBIREO
PARTIAL ECLIPSE OF THE MOON
AUGUST 25-26
POLARIS
UPPER CULMINATION
VENUS RISES
VENUS SETS
MERCURY RISES
MERCURY SETS
TWILIGHT
SYMBOLS:
NEW MOON
FIRST QUARTER
FULL MOON
LAST QUARTER
GREATEST ELONGATION
QUADRATURE
OPPOSITION
GREATEST BRILLIANCY (VENUS)
CONJUNCTION
MERCURY
VENUS
EARTH
MARS
JUPITER
SATURN
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SET TO SIDEREAL TIME
NORTH DECLINATION
SETTING
SOUTH DECLINATION
MEASURE

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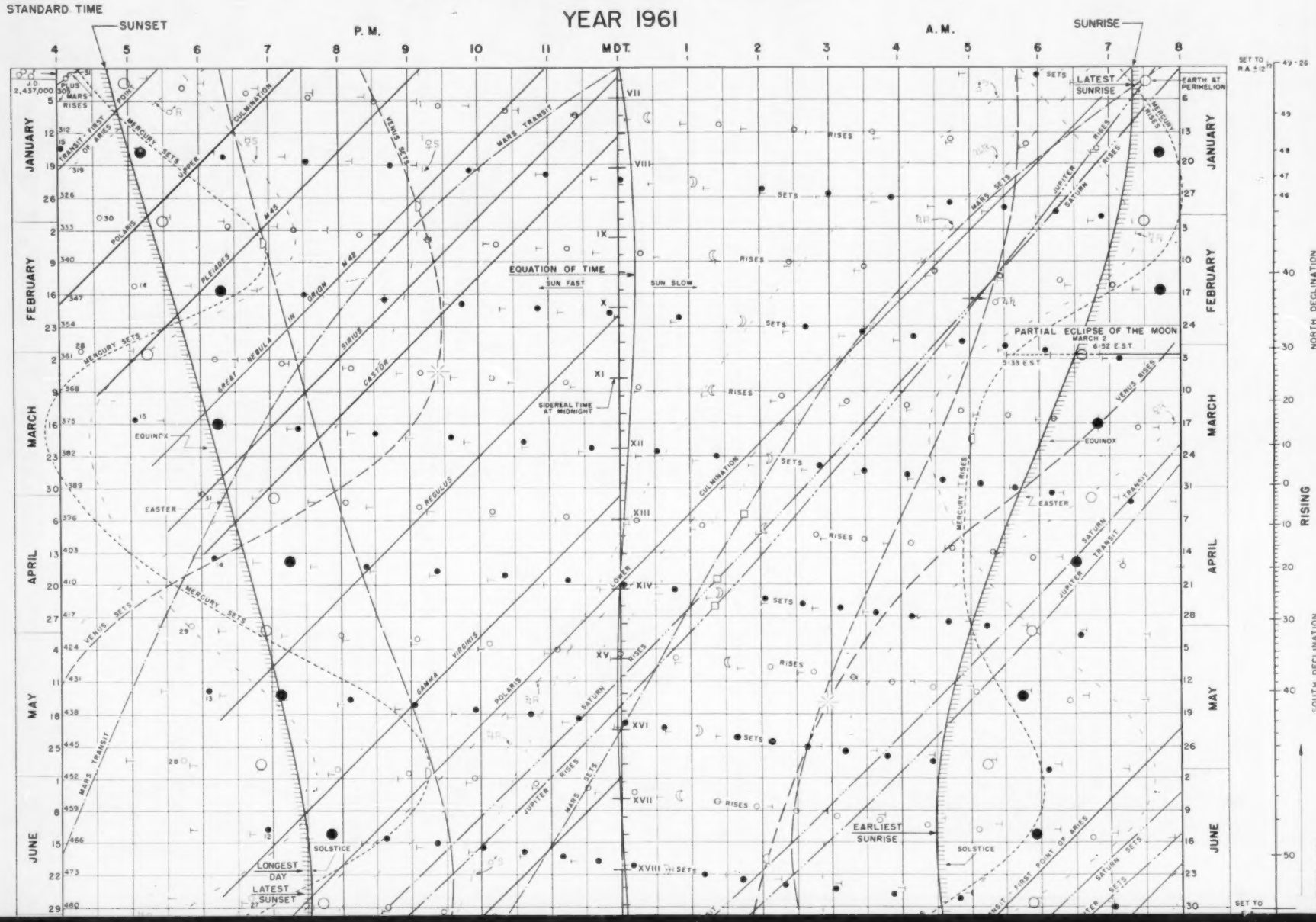
GRAPHIC TIME TABLE OF THE HEAVENS

YEAR 1961



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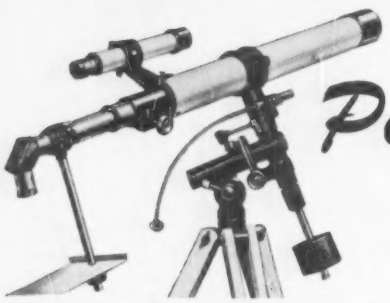

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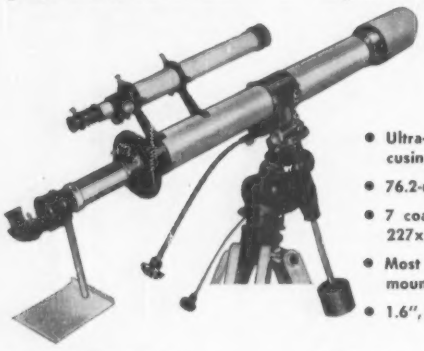

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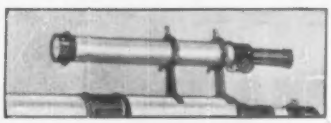

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OBSERVER'S PAGE

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A Brilliant November Aurora

A SOLAR FLARE of great violence, recorded on the morning of November 12, 1960, at Holloman Air Force Base in New Mexico, heralded a spectacular northern lights display witnessed over much of the United States that evening. It was seen as far south as Miami, Florida, and west to Colorado, and received prominent mention in many newspapers.

One of the best views of the aurora by amateurs reporting to Sky and Telescope was obtained by airline pilot R. E. Fried of Atlanta, Georgia, who was flying over Mississippi. He first detected it at 6:35 p.m. Central standard time, and 15 minutes later the display reached from Alkaid to Capella. Apple green curtains extended to about eight degrees above the entire length of the northern horizon, with brilliant pinkish ones running up to within five degrees of Polaris. Areas of deep pink haze were centered at Ursa Major and Auriga.

At Bastrop, Louisiana, George A. Chain at first thought the deep reddish glow he saw in the north was a fire, since he had never observed an aurora of this type at his latitude. It was so bright that the 2nd-magnitude stars in the handle of the Big Dipper were only faintly visible through the glow, which extended almost up to Polaris.

Many observers commented on the redness of the display. It was a blood red for Frank Reed, Louisville, Kentucky, and a dark red for Samuel Whitby, Brodnax, Virginia. The coloring was also noted by J. R. Otoupalik, Greeley, Colorado; Mrs. J. D. Spradley, St. Augustine, Florida; J. Hills, Independence, Kansas; N. Wright, Jefferson City, Missouri; J. M. Downie, Sanderson, Texas; G. W. Shultz, III, Conshohocken, Pennsylvania; and members of Our Lady's Astronomy Club in Carthage, Missouri.

The aurora was watched by Howard Ritter of Oxford, Ohio, from 7:50 to 9 p.m. EST, and by Fred Donaldson and several other members of the Ohio Valley Amateur Astronomers in Steubenville, Ohio, who also photographed the event. Rayed arcs were seen by George Rippen, Madison, Wisconsin. He observed the spectrum of the red region, noting the characteristic lines of neutral oxygen.

Later that evening, white northern lights were spotted by Robert Siebert, Jeanette, Pennsylvania. Dale Schubert, of Newton Highlands, Massachusetts, took several pictures between midnight and 2 o'clock EST, one of which is reproduced here.

At Paterson, New Jersey, the November 12th aurora became faintly visible during dusk, and by 7:30 EST was at its height. Major streamers of strong red were seen by Philip Del Vecchio, and there was a strong green ray in the north. A rare red corona was seen, with a bluish white southern border, that remained almost stationary overhead for nearly half an hour.

Mr. Del Vecchio points out that solar activity in the first half of November was very intense. On the 5th a large sunspot appeared on the sun's eastern limb, and by the 14th it had expanded into 17 spots covering an area of 2,085 millionths of the solar disk. On the 10th, a flare of importance 3 occurred in this sunspot

In Massachusetts, Dale Schubert used an f/2.8 lens and Panatomic-X film to record this bright auroral form in the southwestern sky. The stars of Orion are conspicuous at the left in this two-minute exposure.

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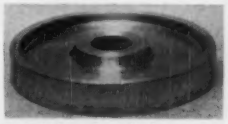

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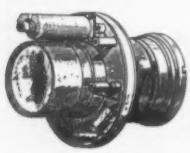

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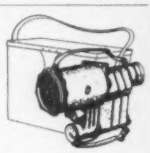

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group, and on the 12th and 15th, flares of importance 3+ were seen at observatories in Michigan and Japan.

On November 12th the IGY World Warning Agency issued an advance alert, and this was followed by a Special World Interval when a great magnetic storm began at 13:50 UT, the "K" index reaching a value of seven on a scale of zero to nine. Half a day later the great aurora was at its height.

Other amateurs who sent in reports include W. Feibelman, Pittsburgh, Pennsylvania; W. Hladky and J. Reiter, Ridgewood, New Jersey; J. Vorreuter, Lakemont-on-Seneca, New York; L. Bonczar, Lowell, Massachusetts; T. Maynes, Littleton, New Hampshire; A. Burstiner, Etters, Pennsylvania; J. Starbird, Topeka, Kansas; M. Zapolski, Schenectady, New York; J. A. Loudon, Philadelphia, Pennsylvania, who observed from Millville, New Jersey.

VENUS-JUPITER CONJUNCTION

On the evening of November 18, 1960, Jack Hills in Independence, Kansas, obtained this photograph of the conjunction of two bright planets. They are seen just above the house, brilliant Venus below and to the left of Jupiter. Mr. Hills used an f/2.5 Aero-Ektar lens and Ansco Super-Hypan film for his 20-second exposure. The stars forming the Milk Dipper in Sagittarius appear over the tree.

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SOUTH of the crater Manilius and north of the Ariadaeus rille is a mountainous region that contains the walled plain Boscovich. Approximately 27 miles in length according to J. Young's measurements, its shape is irregular, although roughly rectangular. While relatively inconspicuous when near the terminator, Boscovich stands out at full moon because of its very dark floor.

Its walls tend to be low and uneven, with many enclosures and openings that lead into the surrounding highlands. The highest part of the rampart is on the west, where the large mountain Boscovich Beta casts a prominent shadow at sunrise. Even after the neighborhood has become fully sunlit, shadow lingers on the side of Beta. Various observers have reported several very minute craterlets on the floor, all but one being difficult to detect in telescopes of moderate size. The floor itself seems lower than the adjacent surface, suggesting that this feature may be a sunken portion of the lunar crust.

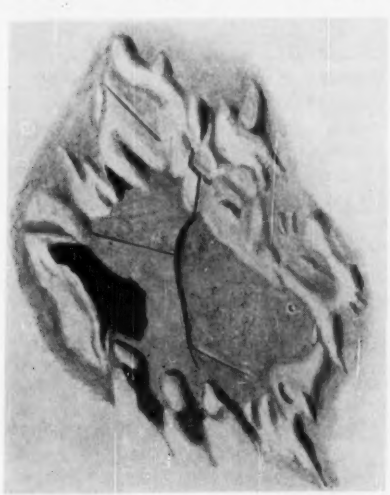
Of most interest in Boscovich is the great fault that crosses the interior. As the accompanying drawing shows, it begins at the base of the southeast wall, extends northward across the floor, and terminates in two short diverging clefts. Near the southern end of the fault is another short cleft, and still another runs from near the mid-point of the fault toward the west wall. Thus it would seem that the floor of Boscovich may have broken into several blocks, each at a different level.

The Boscovich fault appears to be similar in nature to the well-known Straight Wall and the large fault near Bürg (SKY AND TELESCOPE, April, 1960, page 357). All three of them have their high sides on the west.

The interior is notable as one of the darkest areas on the moon. Long ago, E. Neison assigned it a brightness of 1½ on a scale in which 0 represents black shadow and 10 the most brilliant lunar features. The floor is darker than Plato's, for, unlike Plato, Boscovich does not seem to possess the light streaks and spots that would tend to brighten it toward full moon.

The peculiarities of Boscovich gain new significance from a comparison with its wider surroundings. J. H. Mädler in 1837 commented on the great similarity of this object to neighboring Julius Caesar, "in practically every respect, save in being smaller and having a lower wall." Consider also the curious feature Boscovich P, immediately adjoining to the north. It is best described as an elongated, rectangular, sunken plain, sharing the warping characteristic of Boscovich. As Gilbert Fielder's photographs and chart show (April, 1960, issue, page 334), these peculiarities seem to have resulted from a systematic deformation of a large area of the moon's surface.

ALIKA K. HERRING
1312 Arlington Ave.
Anaheim, Calif.



South is above and west to the left in this drawing of the lunar formation Boscovich, made by Alika Herring on May 15, 1959, at 4:05 Universal time. He used 354x on his 12½-inch reflector. The sun was about 10 degrees high, as seen from Boscovich's floor where the very prominent shadow of the peak Beta falls.

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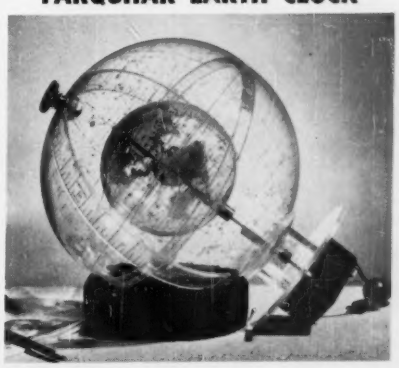

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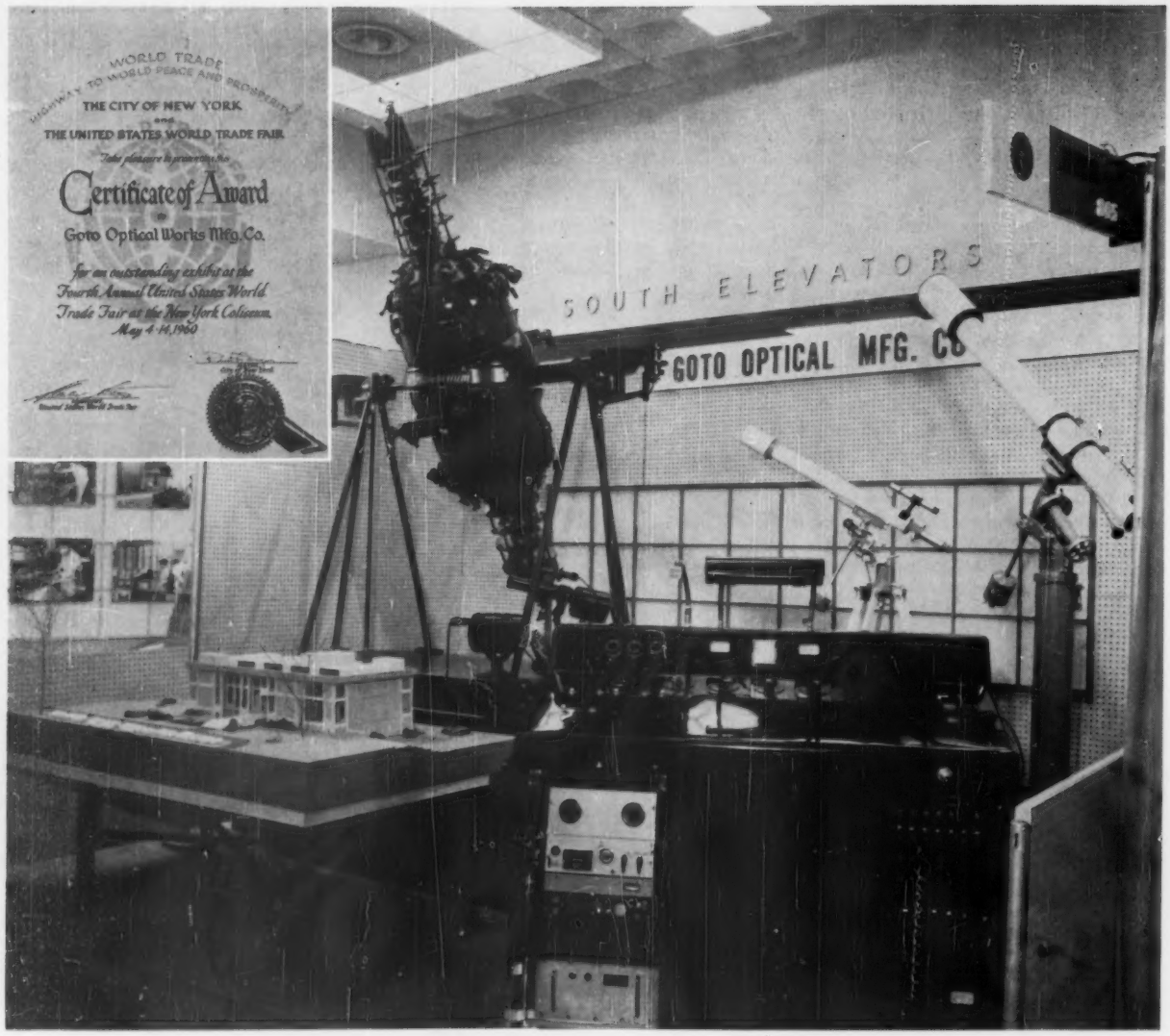
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THE NORTH STAR'S RING

WITH my 7 x 50 binoculars and good seeing conditions, I have often observed what I call the "engagement ring" of Polaris. It is a fairly round circlet about one degree in diameter, formed by the five brightest stars within two degrees of the North Star.

The solitaire is bright Polaris, which is on the side of the ring toward the celestial pole. At the present time Polaris is 55 minutes of arc from the pole, above it when the local sidereal time is two hours.

The accompanying photograph, taken by Andrew Frame of Darien, Connecticut, is one of the few pictures I have seen that shows this ring of stars to advantage. When looked at through a telescope's finder, the circlet is too small to be noticed; it is also too faint unless viewed with a 2-inch objective. On the other hand, in a telescope with a power of 30 or more the field may be less than the ring's diameter.

WILLIAM L. DUTTON
Box 331
Noroton, Conn.

SUNSPOT NUMBERS

The following American sunspot numbers for October have been derived by Dr. Sarah J. Hill, Whitin Observatory, Wellesley College, from AAVSO Solar Division observations.

October 1, 11; **2,** 24; **3,** 20; **4,** 43; **5,** 75; **6,** 73; **7,** 112; **8,** 94; **9,** 138; **10,** 143; **11,** 103; **12,** 119; **13,** 98; **14,** 93; **15,** 96; **16,** 91; **17,** 88; **18,** 68; **19,** 68; **20,** 70; **21,** 63; **22,** 47; **23,** 47; **24,** 52; **25,** 53; **26,** 53; **27,** 57; **28,** 48; **29,** 70; **30,** 64; **31,** 72. Mean for October, 72.7.

Below are provisional mean relative sunspot numbers for November by Dr. M. Waldmeier, director of Zurich Observatory, from observations there and at its stations in Locarno and Arosa.

November 1, 76; **2,** 80; **3,** 69; **4,** 58; **5,** 73; **6,** 90; **7,** 116; **8,** 125; **9,** 125; **10,** 125; **11,** 134; **12,** 132; **13,** 128; **14,** 132, **15,** 133; **16,** 121; **17,** 103; **18,** 82; **19,** 74; **20,** 82; **21,** 65; **22,** 57; **23,** 57; **24,** 41; **25,** 42; **26,** 60; **27,** 58; **28,** 56; **29,** 53; **30,** 63. Mean for November, 87.0.

ORIONID METEORS IN 1960

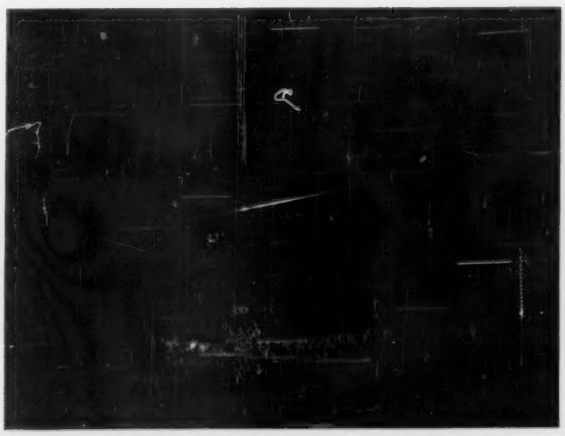
SINCE becoming a member of the American Meteor Society two years ago, I have observed over 1,200 meteors visually and have photographed about 25 bright ones on fewer than 200 exposures.

On October 20-21, 1960, our small group of observers at Tujunga, California, made visual and photographic observations of the Orionid shower. Between 1:30 and 2:30 a.m. Pacific standard time, J. Bias counted 31 meteors, and 23 from 2:30 to 3:30. I took 10 photographs with a 35-mm. Minolta camera, whose 35-mm. lens covered a 60-degree field. Two meteors were filmed, both noted visually as being brighter than 1st magnitude and leaving trains.

The following night, 10 more exposures gave images of three additional meteors. Another observer counted 21 and 27 meteors in the one-hour intervals starting at 1:30 and 2:30 a.m., respectively.

On both nights sky conditions were ideal, with no interference from city lights. The temperature never dropped below a fairly comfortable 62°.

NORMAN D. PETERSEN
6836A Valmont St.
Tujunga, Calif.



An Orionid meteor of visual magnitude zero recorded on Tri-X film by Norman D. Petersen. He began the exposure at 2:56 a.m. Pacific standard time, October 21, 1960, and closed the shutter a minute after the meteor appeared at 3:04 a.m. Traveling toward Leo between Cancer and Hydra, the Orionid had a five-degree trail, was orange-red, and left a train that persisted for 20 seconds.

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WHAT OF 1961?

Our first task: For some time our catalogue has listed 240 proposed slides of drawings of the skies, from the equator to 80° north and 80° south -- a bigger job than anticipated, particularly in view of the limited time we can spend on them. These slides are to be for every 20 degrees north and south, for the 15th of the month. When this ad appears, we hope to have slides Nos. 1001 to 1072 ready, and up to No. 1120 by February or March, with navigation stars to follow. Then more slides are to show individual constellations, with more material than is found on any one diagram, plus many NGC objects, for real educational value.

Last October, we purchased and had completely overhauled a Kodagraph microfilm camera that originally cost about $2,500 with its auxiliary equipment. In the hands of a competent and experienced photographer, this camera should enable us to increase the quality of our 35-mm. slides. We will be able to process all of our slides directly.

Besides the slide sets mentioned above, we hope to add others this year. With increased interest in the moon and the possibility of landing someone there soon, we will have more lunar slides. One unfulfilled dream of 1960 — color slides — is also a goal.

Another project is a greatly expanded list of paper-bound books. Many young people with limited funds are science-minded, and we want to make more material available to them, as well as to persons on a limited budget who want to read more astronomical books.

Astronomy Charted wishes everyone who reads this advertisement a very happy, prosperous, and satisfying New Year, and invites you to write us for a copy of our catalogue. We hope to serve you better in 1961.

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DEEP-SKY WONDERS

DURING January evenings the strip of sky between right ascensions 5^h and 6^h moves up the eastern sky and is accessible through most of the dark hours. Therefore this is a timely season to examine this region, which extends southward from the north celestial pole through Auriga, Orion, and Lepus. Listed here are seven of its clusters, nebulae, and galaxies, some familiar and others little known to amateurs.

Northmost of the septet is NGC 1857, a galactic cluster at the edge of the Milky Way in Auriga, right ascension 5^h $16^m.6$, declination $+39°$ $18'$ (1950 co-ordinates). About $9'$ across, it is a grouping of some 45 stars, one of them 7th magnitude. In Norton's *Star Atlas* it is labeled 33f, as the 33rd object in William Herschel's class VII (pretty much compressed clusters). He described it as "considerably rich."

Farther south, near Zeta Tauri, is the famous Crab nebula, Messier 1 or NGC 1952. It is a planetary nebula, $6'$ by $4'$ in size, at 5^h $31^m.5$, $+21°$ $59'$. Small telescopes show a feebly luminous, oval mass, with no hint of structure. Actually, there is a wealth of spidery detail, as shown in the red-light photograph by the 120-inch Lick telescope on page 6 of last July's SKY AND TELESCOPE. Lord Rosse long ago made out some of this pattern visually. Can a modern 10- or 12-inch reflector reveal it with the aid of a red filter?

Look near 11 Orionis for the broad, splashy cluster NGC 1817, at 5^h $09^m.2$, $+16°$ $38'$. Like NGC 1857, it is a gathering of stars in an already rich field. To me, its $15'$ diameter seems to include more than the 10 stars mentioned in some catalogues.

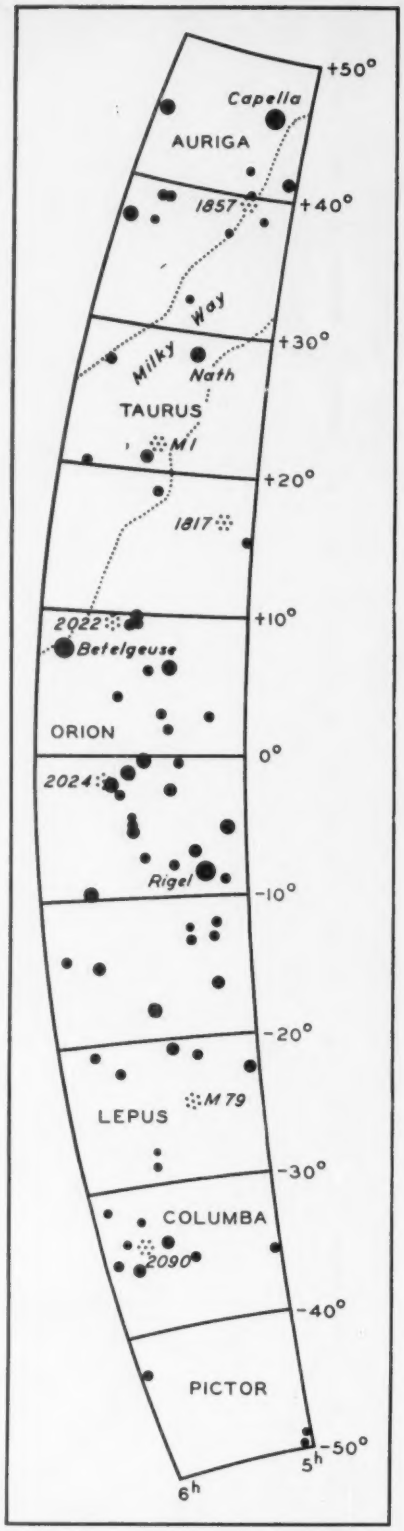
The planetary nebula NGC 2022, another of William Herschel's discoveries, is located at 5^h $39^m.3$, $+9°$ $03'$, also in Orion. Its dimensions have been cited as $28''$ by $27''$ from photographic measurements, but visually it looks smaller; a power of 75 will distinguish it from nearby stars. I suspect that many amateurs have never seen this faint planetary, but it was easy in a 6-inch at Cincinnati.

Just east of Zeta Orionis is NGC 2024, a rather difficult nebulosity half a degree in diameter, at 5^h $39^m.4$, $-1°$ $52'$. A rich-field telescope or a Moonwatch apogee instrument can show it, but bright Zeta should be kept out of the field. William Herschel discovered it on New Year's Day, 1786, with an 18.7-inch reflector, and recorded: "Wonderful black space included in remarkable milky nebulosity, divided in 3 or 4 large patches; cannot take up less than ½ degree, but I suppose it to be much more extensive."

Farther south, in the constellation Lepus, is the fine globular cluster NGC 1904, better known as Messier 79, even though it was actually first seen by his colleague P. Méchain. This compact stellar swarm has a total brightness matching an 8th-magnitude star. Its co-ordinates are 5^h $22^m.2$, $-24°$ $34'$.

For observers in the southern United States, our tour may be extended to include NGC 2090, a 12th-magnitude spiral galaxy in Columba, at 5^h $45^m.2$, $-34°$ $15'$, and only $2½'$ by $1'$ in size. The *New General Catalogue* by oversight called it a globular, copying a poor observation by John Herschel, while missing his later, correct description as "bright, irregular, gradually much brighter toward the middle."

WALTER SCOTT HOUSTON
36 Lawn Ave.
Middletown, Conn.



All of the clusters and nebulae that are mentioned in this month's Deep-Sky Wonders are plotted in this chart, adapted from Norton's "Star Atlas." The brighter stars and the boundaries of the Milky Way are given. The four-digit designations are from the "New General Catalogue" of J. L. E. Dreyer.

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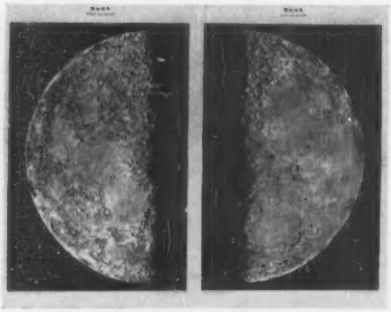

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BOOKS AND THE SKY

THE RADIO NOISE SPECTRUM

Donald H. Menzel, editor. Harvard University Press, Cambridge, Mass., 1960. 183 pages. $7.50.

THE TITLE of this book is somewhat misleading. It suggests that here is yet another of the many works on radio astronomy that have appeared in recent years. Instead, it is a collection of 13 papers presented by radiophysicists during a conference at Harvard College Observatory in 1958.

Primarily, the papers review the various sources of noise and interference that a radio engineer might encounter. Such natural sources as the sun, the planets, and the galactic radio background are treated, together with "whistlers," very low-frequency radiation (0.003 to 3,000 cycles per second), and man-made interference. The accounts of radio noise at frequencies less than 10 megacycles per second would not be found in most books on radio astronomy. In addition, there are chapters dealing with the radio reflection properties of meteors and aurorae, which seem outside the scope of a book with this title. The justification for introducing these subjects is that they are mechanisms by which radio interference may be scattered to locations otherwise free of noise.

Donald H. Menzel is to be congratulated on securing as contributors the leading scientists in most of the fields covered by the conference. Some of the studies are in their infancy, and it is encouraging to find that experiments having largely negative results, such as those described by G. S. Hawkins concerning the search for magnetic effects and radio noise generated by meteors, are given as much space as the well-established subjects. In this connection, it seems a pity that no one with direct experience was present to give an account of the experiments to detect radio noise from the aurora. Such work, also a new topic, gets only a mention in the chapter by A. M. Peterson dealing with radar echoes from the aurora.

Older branches of radiophysics, like the study of solar or planetary radio noise, are well described for the most part. The language is kept simple and can be comprehended easily by engineers unfamiliar with these fields. Mathematical equations have been omitted wherever possible. Where formulae constitute an essential part of the discussion, they are introduced in final form, with references to the papers in which they were originally derived.

An example of this is Von R. Eshleman's chapter on the radio reflecting properties of meteor trails. Dr. Eshleman succeeds in the difficult task of explaining this complicated subject without recourse to a great deal of mathematics, and gives an adequate list of references for those who wish to pursue the subject further. Equally good accounts are given by Dr. Peterson on the reflection properties of aurorae, B. F. Burke on noise of planetary origin, A. Maxwell, G. Swarup, and A. R. Thompson on the radio spectrum of solar noise bursts, and J. Aarons on the natural background radiation at very low frequencies.

Other chapters might usefully have been expanded. In the one dealing with man-made interference, there is little information concerning the spectrum of this noise. For example, the noise power radiated by the average unsuppressed automobile must surely be known as a function of frequency, and could well have been given here. Other potent sources of radio noise, such as high-tension power lines and neon lighting, might also have been mentioned. Similarly, R. S. Lawrence, in the chapter on ionospheric scintillation of extraterrestrial radio waves, could have included some indication of the amplitude of these fluctuations as functions of frequency, time, and geomagnetic latitude.

Two contributions appear to have been written specifically for the engineer. R. N. Bracewell discusses the effect of aerial beam-width in determining the variation of sky temperature, and Dr. Menzel presents a study of the galactic radio noise measurements by many radio astronomers. He provides grid co-ordinate systems which

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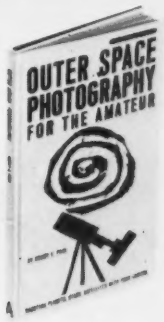

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can be placed over maps of sky temperature to convert azimuth and elevation bearings at a given time to the corresponding right ascension and declination.

The only criticism of the book concerns not what is included but what is left out. Some omissions have been mentioned. Two additional subjects seem to have been neglected or inadequately covered. The first is the variation of atmospheric temperature as a function of elevation angle for a radio telescope operating at centimeter wave lengths. Absorption of radio waves in the millimeter range by oxygen and water vapor in the lower atmosphere is not mentioned. These effects place a limit on the radio-wave spectrum that can be made use of outside the laboratory.

The second neglect is in description of solar radio noise properties. Since the sun is widely used to calibrate those receiving systems insufficiently sensitive or stable to detect any bright radio stars, it would have been useful to have some figures indicating the amount of time that the sun is in its quiet state at different frequencies. Also, the angular diameter of the sun as a function of frequency, and some discussion of the slowly varying component of solar noise, might well have been given.

Despite these omissions, the book is a valuable addition to the literature, and meets a definite need. Without giving a great deal of description of the physical processes involved, it provides radio engineers with well-written accounts of the various natural sources of radio noise. It ends with a plea by T. Gold for protection of radio astronomy frequencies — particularly the hydrogen line at 1420 megacycles. Largely through the efforts of the Dutch, supported by the British and the French, the recent Geneva conference on frequency allocations proposes to give radio astronomers certain limited rights. Although a late starter, the United States will shortly have instruments equal to any elsewhere. It is to be hoped that Professor Gold's warning will be heeded, if these instruments are to be put to good use.

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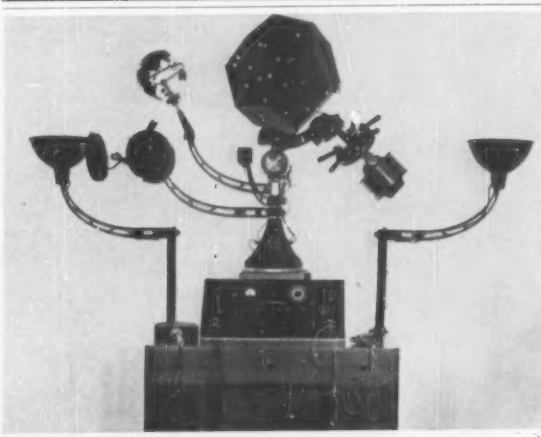

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THE EXPLORATION OF SPACE

Robert Jastrow, editor. Macmillan Co., New York, 1960. 160 pages. $5.50.

ADVANCES IN SPACE SCIENCE, VOLUME II

Frederick I. Ordway, III, editor. Academic Press, Inc., New York, 1960. 450 pages. $13.00.

THESE TWO BOOKS represent opposite extremes of hard-cover publications on space science. Vol. II of *Advances in Space Science* brings to the reader a collection of reference articles which are a permanent record of the state of space engineering in early 1960. *The Exploration of Space,* on the other hand, is concerned with the scientific aspects of space and provides a platform for expounding new theories and describing recent or proposed experiments. The authors seek to be persuasive rather than thorough.

The latter book contains the proceedings of a symposium held on April 29-30, 1959. Its 13 contributions are, in essence, progress reports. The authors interpret recent data on phenomena of the high atmosphere and the solar system; they argue the relative merits of various theories and propose many experiments to resolve the difficulties.

The scope of the symposium was very broad, covering solid particles in interplanetary space, the solar corona, the Van Allen radiation belts, the Argus experiment, planetary atmospheres, and a summary of the National Aeronautics and Space Administration's plans for vehicle development.

These topics are discussed intensively but briefly. However, the objective of the symposium was not to exhaust the subjects but to "awaken the interest of the scientific community . . . , to present an estimate of present and future capabilities for space exploration," and to challenge the ingenuity of the experi-

mentalist in the construction of new apparatus.

This book has a peculiar vitality, produced by the semiformal air of the major papers as well as the summaries of question periods and the three round-table discussions held during the symposium. The editing is uniformly excellent, and the book is greatly strengthened by the editor's penetrating introductory remarks.

Vol. II of *Advances in Space Science* is a symposium, too, but this by proxy, since the contributors did not face each other physically or mentally. This book treats the technological aspects of space science, a subject less open to controversy than the interpretation of data in *The Exploration of Space*.

The result is a valuable collection of thoroughgoing articles which are, for the most part, complementary. The six subjects are uses of space vehicles for experimental physics, tracking, materials in space, plasma propulsion devices, electrostatic propulsion, and altitude control of artificial satellites and space vehicles.

Each article of this volume contains a lengthy bibliography, in one case comprising 97 entries. The fact that one article, originally planned for this work, was published as a separate book, attests to the thoroughness with which the authors attacked their subjects.

At a time when new ideas in the space sciences appear frequently and in an appallingly wide range of publications, the two books under review provide the specialist with a valuable amalgamation. The nonspecialist is still on his own.

CHARLES A. WHITNEY
Smithsonian Astrophysical Observatory

Films and the Sky

UNIVERSE

National Film Board of Canada. 680 Fifth Ave., New York 19, N. Y., 1960. 16-mm. sound motion picture, 28 minutes. $130.00.

An animation-prize winner at the International Film Festival at Cannes, France, Universe is a black-and-white motion-picture presentation of the realm of the astronomer. Binary stars, planets, and novae are among the celestial objects seen in action through animation.

An all-night observing session with astronomer Donald A. MacRae at the David Dunlap Observatory, Richmond Hill, Toronto, is the setting from which the viewer is drawn into space for a closer look at heavenly objects. Glimpses of life on earth, such as spaghetti cooking and a traffic jam, serve as contrasts to the silent and majestic phenomena of the skies.

Once away from our planet, we see the moon as it progresses through its monthly phases, view other planets from their satellites, and see two galaxies colliding — all by means of the film's excellent animation. Two of the more stirring sequences show the asteroid belt as it might be seen from one of its denser parts, and catch a nova in the process of exploding.

Obviously prepared with expert scientific advice, Universe is generally quite accurate in its presentation. Overdramatization, which easily could have crept in, has been avoided. Several small imperfections do not significantly detract from the film's generally excellent impression. The portrayal of steep lunar mountain slopes is not consistent with our knowledge of the moon's surface. When speaking of Pluto, the narrator mentions that the sun would appear as just another star in that planet's sky. Although the sun would not present a visible disk to the unaided eye, it would be much brighter than any other star, having a magnitude of −19, or 300 times brighter than the full moon seen from the earth.

Universe is an intriguing and informative film. It can well be used as an introduction to astronomy in elementary and high schools, or for adult classes. Amateur groups might also take advantage of its unusual presentation of astronomy for their meetings. Rental copies of this outstanding 16-mm. motion picture may be obtained from Contemporary Films, Inc., 267 W. 25th St., New York 1, N. Y.

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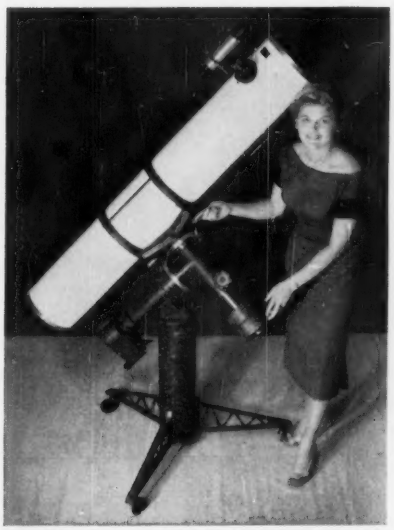

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NEW BOOKS RECEIVED

BEYOND THE PLANET EARTH, *Konstantin Tsiolkovsky,* 1960, *Pergamon.* 190 pages. $3.75.

K. Tsiolkovsky (1857-1935) was a Russian schoolteacher who foresaw clearly the possibility of manned spaceflight. This fictional account of an interplanetary voyage in A.D. 2017 embodies his ideas in detail, and is therefore an important document in the history of astronautics, in addition to its interest as a novel. Kenneth Syers' is the first English translation of this book, originally published in Russian at Kaluga in 1920.

ASTRONOMIE, *Joachim Herrmann,* 1960, *C. Bertelsmann Verlag,* Gütersloh, West Germany. 393 pages. DM 11.80.

The director of a Berlin public observatory presents a conversational, historically oriented summary of all phases of astronomy, intended for the general reader and amateur. The well-illustrated text is in German.

SOURCE BOOK IN ASTRONOMY 1900-1950, *Harlow Shapley,* editor, 1960, *Harvard University Press.* 423 pages. $10.00.

A comprehensive view of major advances in a half century of astronomy is provided by excerpts from 69 of the most important writings of the period. These have been selected to be understandable by the informed layman, and range in subject from the 200-inch telescope and the coronagraph to relativity and cosmogony. This is a companion volume to Dr. Shapley's 1929 collection, *A Source Book in Astronomy* (with H. E. Howarth), of selections up to the year 1900.

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THE HANDBOOK OF THE BRITISH ASTRONOMICAL ASSOCIATION, 1961, *Cameron Dinwoodie,* editor, 1960, *British Astronomical Association,* 303 Bath Rd., Hounslow West, Middlesex, England. 71 pages. $1.40 for nonmembers, paper bound.

This is the 40th annual *Handbook* of the BAA, this year under the editorship of Cameron Dinwoodie, succeeding J. G. Porter. It contains the same useful information for observers as in preceding years, including occultation predictions for eight stations in Great Britain, South Africa, Australia, and New Zealand.

Predicted positions are given for the sun, moon, and planets, as well as for periodic comets due to return in 1961. Specialized information is provided for lunar, planetary, and meteor observers, and on many other topics.

Although the charts on page 42 for Saturn's moon Titan have south upward, those on page 43 for Iapetus are north up.

AN INTRODUCTION TO ASTRODYNAMICS, *Robert M. L. Baker, Jr.,* and *Maud W. Makemson,* 1960, *Academic.* 358 pages. $7.50.

This textbook on celestial mechanics is especially intended for engineers and others concerned with space travel who have a sound mathematical background but little formal familiarity with astronomy. The treatment, from the viewpoint of the space technologist rather than the pure astronomer, ranges from co-ordinate systems to the calculation of perturbations of space vehicles. The authors are members of the astronomy department of the University of California at Los Angeles.

CLASSICS IN SCIENCE, 1960, *Philosophical Library.* 322 pages. $6.00.

Forty-three brief excerpts, mostly of a popular nature, are chosen from the writings of scientists in many fields to give a bird's-eye view of what science is about. The 14 bearing on astronomy are by such men as Ptolemy, Galileo, and Eddington.

A COMPENDIUM OF SPHERICAL ASTRONOMY, *Simon Newcomb,* 1960, *Dover.* 444 pages. $2.25, paper bound.

For the astronomer who has to deal with accurate star positions or proper motions, Newcomb's *Compendium* contains the practical experience of the lifetime work of an outstanding expert. There are detailed mathematical developments of refraction, aberration, precession, and nutation, and a full explanation of the formation of star catalogues and the derivation of systematic corrections to catalogues. The present edition is a reprint of the original one of 1906.

SEEING COLOURS, *J. Bergmans,* 1960, *Macmillan.* 80 pages. $3.00.

Translated by T. Holmes from the Dutch, this short book is a simply written survey of visual color perception. Intended as an elementary text, it contains much background information for advanced amateur astronomers.

READABLE RELATIVITY, *Clement V. Durell,* 1960, *Harper.* 146 pages. $1.25, paper bound.

First published in London in 1926, this informative book is a layman's introduction to relativity, employing only simple mathematics.

THE OBSERVER'S HANDBOOK 1961, *Ruth J. Northcott,* editor, 1960, *Royal Astronomical Society of Canada,* 252 College St., Toronto 2B, Ontario. 90 pages. $1.00, paper bound.

This valuable aid to the amateur astronomer is now in its 53rd year. It contains monthly listings of celestial phenomena, including data on the sun, moon, planets, Jupiter's satellites, meteor showers, and occultations for 1961. There are compilations of variable stars, double stars, clusters, nebulae, and galaxies suitable for amateur observing. The 286 stars brighter than magnitude 3.55 are listed with their colors, spectral types, motions, distances, and absolute magnitudes. Constellation name pronunciations have been added.

AN INTRODUCTORY TREATISE ON DYNAMICAL ASTRONOMY, *H. C. Plummer,* 1960, *Dover.* 343 pages. $2.35, paper bound.

First published in 1918, this classic textbook is famous for its thorough coverage of celestial mechanics. Besides methods for computing orbits and perturbations, the many topics discussed include lunar theory, double stars, and precession. The treatment is on a graduate-student level.

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Cat. #BPA-36 for 1¼" eyepiece holders..**$22.50**
Cat. #BPA-37 for 4" standard Dynascopes **$21.00**

New!

Dyn-o-Astro 35-mm. Camera at less than regular price of camera alone!

No need to be an expert photographer to take exciting astrophotos with this *single-reflex*-type, precision-made 35-mm. camera. No complicated settings. No plates or filmholders to load and unload. No worries about missing target. Large focusing screen shows you *exactly* the viewing field up to moment of shooting.

- No accidental double exposures. Winding knob automatically advances film, positions mirror, winds shutter, counts exposures.
- Dual-speed setting knob controls both fast and slow shutter speeds. Color coding makes mistakes impossible.
- Integrated magnifier for critical focusing even on dim objects.

Takes time exposures and also has speeds up to 1/500 second. Guaranteed for 2 years. Complete, ready for use.

Model CP-35 fits 1¼" eyepiece holder **$89.00 postpaid**

Model CP-36 fits all standard 4" Dynascopes **$85.00 postpaid**

Dyn-o-Swing Camera Support

fits any 4" or 6" telescope without drilling!

Takes guesswork out of astrophotography by providing *precise centering* of camera over eyepiece. Smooth rack-and-pinion adjustment. Easily attached or detached from tube, with rigid clamp for maximum stability. Special arm lets you swing camera away from eyepiece for visual observation, with instant return for photographing. Can be used with almost any camera. Postpaid.

Cat. #CS-4 to fit all 4" Dynascopes..... **$17.50**
Cat. #CS-47 to fit all 4¼" O.D. tubes..**$18.95**
Cat. #CS-67 to fit custom 6" Dynascope and 7¼" O.D. tubes..... **$19.95**

Catalog F, describing other accessories and parts, cheerfully sent on request. Satisfaction guaranteed, or money refunded. All items sent postpaid. We pay all postage costs. No shipping, crating, or packing charges. Send check, cash, or money order for immediate delivery.

Criterion Achromatic Barlow

This precision Barlow features an achromatic, coated lens, perfectly centered and corrected for finer resolution than you've ever experienced. Intensively tested and proven superior, achromatic lens is mounted in a precision cell. Gives 2.4x magnification. Definition is clear and sharp, hard to the very edge.

Model CP-4 fits standard 1¼" eyepieces..**$17.50**
Model CP-2 fits small 0.946" eyepieces....**$15.50**

Paraboloidal Mirrors

Aluminized, zircon-quartz overlaid. Guaranteed unconditionally to perform to the limits of resolution. Hand-corrected to exacting specifications, and guaranteed superior.

4" f/8	**$42.00**
4" f/10	**31.00**
6" f/8	**55.00**
6" f/9	**50.00**
8" f/8	**89.00**
10" f/7	**179.00**
12½" f/7	**299.00**

All **mirrors** made of **PYREX**-brand glass

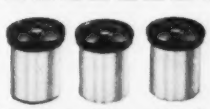
A tolerance of 5% in focal length is customary. A deposit of ⅓ is required with orders for 8" to 12½" mirrors.

Reflecting Telescope Mirror Mounts

Mounting the mirror to your scope correctly is most important. Criterion mounts are especially well designed, and are made of cast aluminum with brass mounting and adjustment screws. One section fits tube, other section holds mirror. Alignment accomplished by three spring-loaded knurled adjusting nuts. Outer cell designed to fit into or over your tube. Sufficient space left between the two cells. All drilled and tapped. Complete with holding clamps, springs, nuts, etc. Ready for use. Will prevent vibration and hold alignment once set. Will hold mirror without distortion of surface figure.

3"	**$3.00**	6"	**$6.50**
4"	**3.50**	8"	**12.50**
5"	**4.00**	10"	**19.50**

Complete Eyepieces



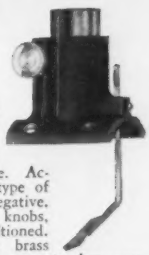
Finest quality. They are precision machined, mounted in standard 1¼" outside diameter barrels. Can be taken apart for cleaning. Designed to give sharp flat field clear to edge.

Huygens 18-mm. f.l. (¾")	**$ 7.50**
Kellner 9-mm. f.l. (⅜")	**7.90**
Kellner 7-mm. f.l. (9/32")	**8.50**
Kellner 12.7-mm. f.l. (½")	**9.50**
Kellner 18-mm. f.l. (¾")	**9.50**
Kellner 30-mm. f.l. (1-3/16")	**12.50**
Orthoscopic 6-mm. f.l. (¼")	**12.50**
Orthoscopic 4-mm. f.l. (5/32")	**14.50**

Revolving Turret

The Criterion Revolving Turret holds three eyepieces so that, as desired, the power of the telescope can be changed by merely turning the turret to a different ocular. Click stop insures positive and accurate positioning of each eyepiece. Turret holds eyepieces of standard 1¼" outside diameter. Fits into the holder of any refractor or reflector telescope that uses 1¼" eyepieces. Requires no alteration or adjustment and can be attached as easily as putting eyepiece into scope. Made of brass and aluminum with polished chrome-plated barrels.
Cat. #SRT-350..... **$14.50**

Rack-and-Pinion Eyepiece Mount



The most mechanically perfect focusing is by rack and pinion. This mount takes standard 1¼" eyepieces. Full 3½" of travel — more than ever before. Accommodates almost any type of eyepiece — positive and negative. Two knurled focusing knobs, variably tensioned and positioned. Solid cast-metal sliding brass tube — close tolerance prevents looseness. Mount aligns itself to any type tube. Four mounting holes, nuts and bolts included. Eye mount has square-rod-type diagonal holder which prevents loose alignment and vibration. Rod tempered to minimize temperature changes. Adjustable for 3" to 8" scopes, also 12" scopes if so specified at no extra cost. Order one or more of the complete eyepieces described below at the same time you send for this rack-and-pinion device, which accommodates any of our eyepieces perfectly.

Cat. #SU-38..... **$7.95 postpaid**

New Model Eyepiece Mount

Same features as above but has wider base that is contoured to match the curve of a 7" to 8" diameter tube. Makes professional appearance. Furnished without Diagonal Rod #SU-9R..**$9.95**

Diagonal Rod — Cat. #SU-9R..... **$1.00**

Achromatic Finder Scopes

Two models: 6x, 30-mm., and 10x, 42-mm. Coated achromatic air-spaced objective, crosshairs, built-in duralumin tube finished in white enamel, dewcap. Sliding focus adjustment. Can also be used as excellent hand telescopes for wide-field views of the sky. Fit Mount Bracket #SF-610.

6 x 30 Achromatic Finder	**$12.50**
10 x 42 Achromatic Finder	**$18.00**
Mount Bracket #SF-610	**$9.95**

Wide-Angle Erfle Eyepiece

Our 16.3-mm. Erfle wide-angle eyepiece has a 75° field. Astonishing wide-angle views. Coated. Highest precision and specifically designed for telescopic use. Chrome barrel. Guaranteed to be superior in every respect.

Cat. #SE-63 — 1¼" O.D. **$18.50**
Cat. #SE-62 — 0.946" O.D. **$16.50**

Four-Vane Diagonal Holders

Criterion 4-vane diagonal mountings are fully adjustable, will hold elliptical diagonals in perfect alignment. Made of brass, chemically blackened. Precision adjusting screws center flat and vary its angle so that primary and secondary mirrors can be set in perfect alignment. Thin vanes with special adjustable studs.

Cat. #	Minor-Axis Size	For Tubes	Price
S-51	1.25"	6½" to 7½"	**$10.00**
S-52	1.30"	6½" to 7½"	**10.00**
S-53	1.50"	8½" to 9½"	**10.00**
S-54	1.75"	9½" to 10½"	**12.50**
S-55	2.00"	11" to 11½"	**14.95**
S-56	2.50"	Specify tube I.D.	**19.95**

CRITERION MANUFACTURING CO.

Manufacturers of Quality Optical Instruments

Dept. STP-27, 331 Church St., Hartford 1, Conn.

This 4" UNITRON is yours for only $128 down

You can tell at a glance that here is a telescope designed to achieve professional results. Indeed, this 4" UNITRON has been chosen for important research by university observatories, the U. S. and foreign governments, and leading industrial laboratories. Ownership of such a superb instrument might be thought to be beyond the means of many amateur astronomers, yet a 10% down payment of only $128 puts you at the controls of this magnificent UNITRON.

The full purchase price of $1280 includes everything the serious observer wants and needs to make the most of his observing — clock drive, fixed pier, Astro-camera, 2.4" photographic guide telescope, Super-UNIHEX, large 42-mm. 10x view finder, eyepieces, and a complete selection of accessories in addition to these pictured above.

With this 4" UNITRON, you have at your disposal a complete range of magnifications: 25x, 38x, 60x, 83x, 120x, 167x, 214x, 250x, 300x, 375x. And, with the Super-UNIHEX Rotary Eyepiece Selector, you can switch from a spectacular wide-field view of the sky to high-power observation of planetary details at a flick of a finger.

There are other UNITRON 4" models for as little as $465 complete ($46.50 down) and other UNITRON Refractors for as low as $75 ($7.50 down). All may be purchased using our Easy Payment Plan. Whichever model you choose, you are assured of obtaining the finest instrument in its class. After all, it is a UNITRON.

See the back cover.

UNITRON INSTRUMENT COMPANY • TELESCOPE SALES DIVISION, 66 NEEDHAM ST., NEWTON HIGHLANDS 61, MASS.

Choose UNITRON for optical and mechanical excellence

NEW ACHROMATIC AMPLIFIER NOW FREE with each UNITRON

UNITRON's new "Achromatic Amplifier" is a two-element, Barlow-type, negative amplifying lens designed especially for UNITRON Refractors. When used with a UNITRON eyepiece, it **doubles** the normal magnification of the telescope. Here is an ideal way to increase the usefulness of each eyepiece and to obtain the high magnifications that you have always wanted for planetary and lunar observations. The magnification factor of 2x has been selected as the most useful for general amateur observing under a wide variety of atmospheric conditions.

Two types of mounting cells are offered: one to fit the UNIHEX Rotary Eyepiece Selector and one for the UNITRON Star Diagonal. Either type can be inserted or removed in a jiffy. There are no cumbersome tubes to attach, nor ever any need to adjust the focus of the "Achromatic Amplifier." You merely use your regular standard or accessory UNITRON eyepieces in the UNIHEX or star diagonal in the customary manner. The unique optical design matches the UNITRON objectives and eyepieces to insure sharp definition without loss of resolution.

This useful and valuable accessory **is now included as standard equipment** with all UNITRON Refractors at **no additional cost** . . . another of the many reasons why the telescope you choose should be a UNITRON.

The new "Achromatic Amplifier" will be offered as a separate accessory to those who already own UNITRONS. Further details will be announced.

HOW TO ORDER A UNITRON

Send check or money order in full or use our Easy Payment Plan, as described below. Shipments made express collect. Send 20% deposit for C.O.D. shipment. UNITRON instruments are fully guaranteed for quality, workmanship, and performance, and must meet with your approval or your money back.

Use Our EASY PAYMENT PLAN

UNITRON's popular Easy Payment Plan is a convenient and economical way to buy your UNITRON Refractor when you do not want to disturb your savings or when you haven't the total cost of the telescope immediately available. The down payment required is 10%. The balance due is payable over a 12-month period, and there is a 6% carrying charge on the unpaid balance. Your first payment is not due until 30 days after you receive the instrument, and if you should want to pay the entire balance due at that time, the carrying charge is canceled. (6" models available on special plan.)

To the newcomer and more experienced astronomer alike, the choice of "the best" telescope is difficult and confusing . . . so many makes . . . so many models. An astronomical telescope must be designed to observe "point sources at infinity," and hence requires a precision optical system for crystal-clear definition. Optics and mountings must be equally precise to track the star or planet. One without the other is useless. Invest in a UNITRON and be certain of combined optical and mechanical excellence.

MANY Models To Choose From!

1.6" ALTAZIMUTH ($7.50 Down) — **$75**
with eyepieces for 78x, 56x, 39x

2" SATELLITE ($7.50 Down) 6x, diagonal — **$75**
eyepiece, altazimuth mount with circles, stand

2.4" ALTAZIMUTH ($12.50 Down) — **$125**
with eyepieces for 100x, 72x, 50x, 35x

2.4" EQUATORIAL ($22.50 Down) — **$225**
with eyepieces for 129x, 100x, 72x, 50x, 35x

3" ALTAZIMUTH ($26.50 Down) — **$265**
with eyepieces for 171x, 131x, 96x, 67x, 48x

3" EQUATORIAL ($43.50 Down) — **$435**
with eyepieces for 200x, 131x, 96x, 67x, 48x

3" PHOTO-EQUATORIAL ($55.00 Down) — **$550**
with eyepieces for 200x, 171x, 131x, 96x, 67x, 48x

4" ALTAZIMUTH ($46.50 Down) with — **$465**
eyepieces for 250x, 214x, 167x, 120x, 83x, 60x

4" EQUATORIAL ($78.50 Down) with — **$785**
eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x

4" PHOTO-EQUATORIAL ($89.00 Down) with — **$890**
eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x

4" EQUATORIAL with clock drive — **$985**
($98.50 Down), Model 160V, eyepieces as above

4" EQUATORIAL with clock drive and metal — **$1075**
pier (**$107.50 Down**), Model 166V, eyepieces as above

4" PHOTO-EQUATORIAL with clock drive and — **$1175**
Astro-camera (**$117.50 Down**), with eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x, 25x

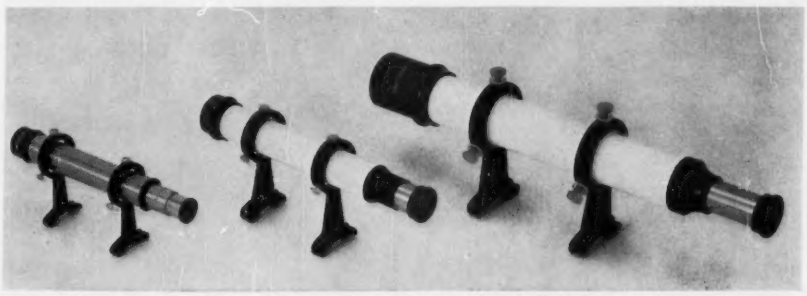
4" PHOTO-EQUATORIAL with clock drive, pier, — **$1280**
Astro-camera (**$128.00 Down**), with 10 eyepieces

Note These UNITRON Features

- LENSES are FULLY CORRECTED for spherical and chromatic aberration and are COATED for maximum brilliance and clarity of image. Optics especially designed for astronomical observation. AIR-SPACED OBJECTIVES.
- REFRACTOR type of design duplicates the performance of larger telescopes of other types. No mirrored surfaces to become oxidized. Superior definition to the very edge of the field.
- EYEPIECES of the HIGHEST QUALITY: Orthoscopic, Achromatized Symmetrical, Kellner, Huygens. Three to ten eyepieces included with each instrument.
- FINEST MATERIALS used throughout. DURALUMIN TUBE. Moving parts of BRASS carefully machined to close tolerances, and finished in CHROMIUM. No surplus components used.
- MODERN DESIGN based on time-tested engineering principles. HANDSOME APPEARANCE to which no illustration can do justice.
- EQUATORIAL MODELS have slow-motion controls for **both** declination and right ascension as well as convenient clamps on both axes. Sturdy TRIPOD (or PIER).
- ALTAZIMUTH MODELS have slow-motion controls for **both** altitude and azimuth as well as clamps for both co-ordinates. Sturdy TRIPOD.
- VIEW FINDER with crosshair eyepiece.
- RACK-AND-PINION FOCUSING.
- Choice of UNIHEX Rotary Eyepiece Selector or STAR DIAGONAL and ERECTING PRISM for TERRESTRIAL OBSERVATION. The same complete range of terrestrial magnifications as for celestial observation.
- SUNGLASS for solar observation.
- ADDITIONAL ACCESSORIES available to add further to your observing pleasure.

Higher- and lower-priced eyepieces available for all models. Prices include basic accessories, tripod and mounting, fitted wooden cabinets, and operating instructions.

New UNITRON View Finders



UNITRON's popular view finders with newly designed optics and mechanical features are better than ever. From left to right: 23.5 mm., 30 mm., 42 mm.

1. VIEW FINDER (Used on UNITRON 2.4" Equatorials): 23.5-mm. (.93") achromatic objective, 6x eyepiece with crosshairs. Chromed brass tube. Mounting brackets with centering screws. **Only $8.50 postpaid**

2. VIEW FINDER (As used on UNITRON 3" Refractors): 30-mm. (1.2") coated achromatic objective and 8x eyepiece with crosshairs. Other details as in View Finder 3. **Only $10.75 postpaid**

3. VIEW FINDER (As used on UNITRON 4" Refractors): 42-mm. (1.6") coated achromatic air-spaced objective. 10x eyepiece with crosshairs. Duralumin tube finished in white enamel. Dewcap. Furnished with mounting brackets, centering screws for collimation, and mounting screws. This finder measures approximately 16" overall. It is light in weight, compact and small enough for use as a hand telescope furnishing spectacular wide-field views of the sky. **Only $18.00 postpaid**

UNITRON

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TELESCOPE SALES DIVISION
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NEWTON HIGHLANDS 61, MASS.

Get UNITRON's FREE Observer's Guide and Catalog on ASTRONOMICAL TELESCOPES

This valuable 38-page book is yours for the asking!

With artificial satellites already launched and space travel almost a reality, astronomy has become today's fastest growing hobby. Exploring the skies with a telescope is a relaxing diversion for father and son alike. UNITRON's handbook contains full-page illustrated articles on astronomy, observing, telescopes and accessories. It is of interest to both beginners and advanced amateurs.

Contents include—

- **Observing the sun, moon, planets and wonders of the sky**
- **Constellation map**
- **Hints for observers**
- **Glossary of telescope terms**
- **How to choose a telescope**
- **Amateur clubs and research programs**

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Please rush to me, free of charge, UNITRON's new Observer's Guide and Telescope Catalog 20-J.

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Precision Diagonals

You will get the best possible performance from your telescope with one of our clear **FUSED QUARTZ** diagonals. Accuracy guaranteed 1/20 wave.

Ellipse 1.25" x 1.77" . . $12.00
Ellipse 1.5" x 2.12" . . $15.00

PYREX-brand glass diagonals, 1/8-wave accuracy.

Ellipse 1.25" x 1.77" . . $ 6.00
Ellipse 1.5" x 2.12" . . $ 9.00

Without aluminum coating, deduct $1.00.

Send for our complete list of supplies, quartz mirrors, blanks, oculars, coatings, and accessories.

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Rectangular shape
1⅜" x 1⅞"
½ wave $1.75 each
¼ wave $4.50 each
Postpaid.

Elliptical shape
Heavy edges to minimize temperature effects.
1¼" minor axis.
½ wave $4.00 each
¼ wave $6.50 each
Postpaid.

BERAL COATINGS — same optical characteristics as aluminum — mechanically more durable — not over-coated — may be removed without harming glass surface. Prices for Beral coating telescope mirrors: 4" diameter—$3.50, 6"—$5.00, 8"—$6.50, 10"—$8.50, and 12½"—$12.50 each, f.o.b. Skokie.

LEROY M. E. CLAUSING
8038 Monticello Ave. Skokie, Ill.

BRANDON OCULARS

These orthoscopic oculars are the choice of the amateur as well as the professional astronomer. Seven sizes available: 4-mm., 6-mm., 8-mm., 12-mm., 16-mm., 24-mm., and 32-mm. focal lengths. Standard 1¼" outside diameter.

$15.95 each

Brandon Oculars may be purchased at —

Cave Optical Co., 4137 E. Anaheim St., Long Beach 4, Calif.

Cleveland Astronomics, 7618 Lawn Ave., Cleveland 2, Ohio

American Lens and Photo Co., 5700 Northwest Highway, Chicago 30, Ill.

Optron Laboratory, Box 25, D.V. Station, Dayton 6, Ohio

Adler Planetarium, 900 E. Achsah Bond Dr., Chicago 5, Ill.

Polaris Telescopic Shop, 14319 Michigan Ave., Dearborn, Mich.

Chuck's Telescopic-Optical Shop, 887 Sherbourne Dr., Inkster, Mich.

—or order direct. We will ship airmail.

LIBRASCOPE P. R.
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Formerly BRANDON INSTRUMENTS

GLEANINGS FOR ATM's

CONDUCTED BY ROBERT E. COX

An 8-inch Fork-Mounted Reflector

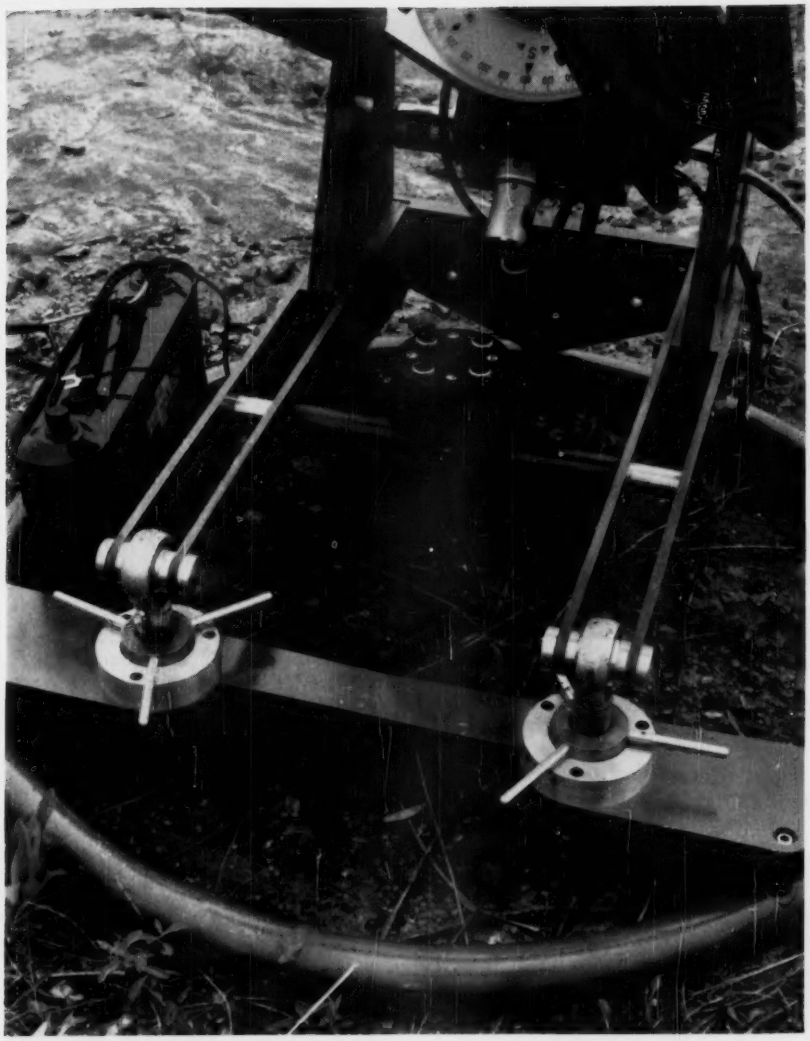
IN DESIGNING a portable mounting for our 8-inch Newtonian telescope, my son and I tried to incorporate several features not provided by a usual tripod. First, compactness was sought with a fork having very short arms, resulting in a low silhouette and excellent mounting stability. Second, we desired a leveling device for adjusting the mounting in the dark without the aid of a flashlight. Third, we wanted a clock drive, with electric push-button slow-motion controls, that would operate from a low-cost 6-volt ignition battery.

With this mounting, however, the eyepiece moves considerably during observing, but the upper tube section can be rotated easily to the most convenient position. At the same time, we made provision for solar and lunar photography, by placing a camera support on the side of the tube opposite the eyepiece. The diagonal mirror is carried on a toggle-controlled assembly which can be flipped to deflect the image to eyepiece or camera.

Except for the base ring of thin-wall steel tubing, the mounting was constructed entirely of 24-ST aluminum. If a welded assembly had been contemplated instead of the bolted one, 61-ST aluminum alloy could have been used. The sheet aluminum, ¼", ½", and ¾" thick, can be readily fabricated with home workshop tools; it was cut with a 12"-capacity bandsaw at wood-cutting speed with a 12-pitch blade.

The cost of aluminum stock, which comprises 95 per cent of the total material, was close to $60, but some of the metal

Richard H. Field, Jr., examines the field of view of the camera attachment on his 8-inch reflector of 64 inches focal length. The Newtonian diagonal mirror has been turned to reflect the primary mirror's image into the camera. All photographs with this article are by R. H. Field, Sr.



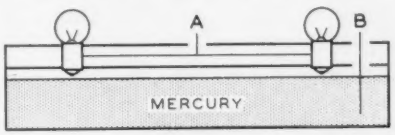
Portions of the 24½-inch base ring with two of the Monoball self-aligning bearings and the spoked-nut leveling screws. At left is the 6-volt battery, and in upper center the round black box of the mercury level indicator. Above it, and below the setting circle, is the lower portion of the clock drive, with one of the two motors visible.

was wasted because of the odd-shaped parts that were cut out. The entire base weighs about 32 pounds, is 26½" high to the center of the declination axis, and the base ring is 24½" in diameter.

At the mirror end of the telescope tube is a heavy counterweight plate, for the declination axis is placed at an 8-to-1 balance point. Thus, for every ounce added at the camera assembly, eight ounces have to be added to the mirror end to restore equilibrium. Our cardboard tube is a disadvantage in this particular design, because it weighs about three pounds per foot. A fiberglass tube would be much more practical, weighing roughly a sixth as much.

As the close-up photograph shows, the base includes a 10° leveling adjustment for sloping terrain. The aluminum mounting is supported on three Monoball self-aligning rod-end bearings, secured to the base ring in tripod fashion. Each of the vertical screws can be adjusted by means of the spoked nut, thereby raising or lowering the mounting while alignment is maintained by the bearing.

For final precise leveling, we have added an electric mercury level indicator, using a go-no-go method. Four flashlight bulbs are equally spaced around the mercury chamber's periphery. Wherever a bulb is lit, the mounting is low, and it



The principle of the mercury level is indicated here, with two light bulbs instead of the four actually used. Inclination of the telescope base causes the mercury surface to contact one of the bulbs. Electrical connections A and B light the bulb.

PARABOLIC MIRRORS OF PYREX-BRAND GLASS

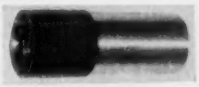
Diam.	*Focal Length*	*Price*
6"	48"	$39.95 postpaid
8"	48"	58.95 postpaid
10"	55"	109.90 postpaid

These mirrors are accurate to ⅛ wave length or better and are free of defects including chips, scratches, and pits. Aluminized reflective coating is protected with quartz overcoating. We invite you to test and compare these with mirrors selling for more. Returnable within 15 days if not pleased.

OVERSTOCKED

1½"-minor-axis elliptical diagonals, aluminized and quartz over-coated. Made of extra-thick fine-annealed PYREX-brand glass. Flat to ⅛ wave or better and free of any defects. While they last. Only $5.95 each, postpaid

MOUNTED BARLOW LENS



This is a special simple lens that fits neatly into your 1¼" focuser and takes any 1¼" O.D. eyepiece. Easily doubles or triples power of your present telescope. No adapters or adjustments necessary. $7.50 postpaid

Unmounted Barlow lens, 1⅛" diam. $3.00 postpaid

BAUSCH & LOMB RED ROUGE

This comes only in factory-sealed cans and is highly recommended for those who want the best. Prompt shipment from stock. Packed 5-lb. can, $8.00 postpaid

WANTED TO BUY: Surplus or discontinued lots of lenses, eyepieces, objectives, and the like.

Write for free catalog.

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Build a powerful precision telescope. Quality supplies and instructions. **$4.50 UP**

6" MIRROR KIT with PYREX-brand blank $9.50

HARD OVER-COATED ALUMINIZING

6" **$3.50** 8" **$4.50**

Superior reflecting surface. Guaranteed not to peel or blister.

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Complete Instructions, 10c. Free Catalog.

Precision Optical Supply Co.

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TRIGARTH TURRET
and
Eyepiece Attachment
with
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Just turn the Trigarth Turret and easily improve the performance of your telescope. It holds three eyepieces of standard 1¼" O.D. The Trigarth Turret sells for **$15.95 postpaid.**

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1 — NEW! 6" reflector, same as above, but with fiberglass tube. **$225.00**

1 — Brass collapsible telescope, on excellent tripod, complete with Linhoff panhead, Bausch and Lomb Adaptoscope, and accessories. Approximately 60 mm., 15 power. This beautiful telescope was made in France. Just the thing for hunting or target spotting. **$67.50**

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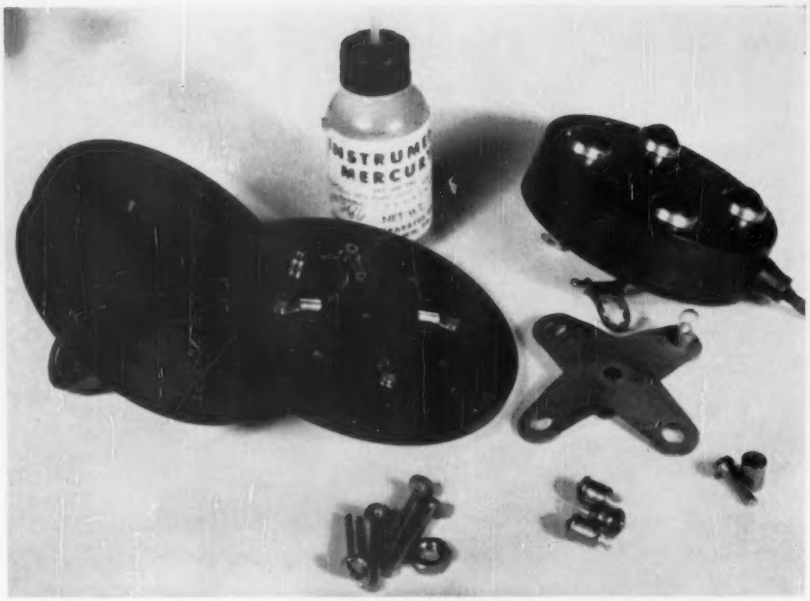


The bulbs of the mercury level indicator are capped with windows of 7/16-inch red pilot-light jewels. The ground contact is installed with a solder lug under its head, and all screw threads are coated with sealing compound.

is only necessary to adjust the spoke-wheel screws until all the lights are extinguished.

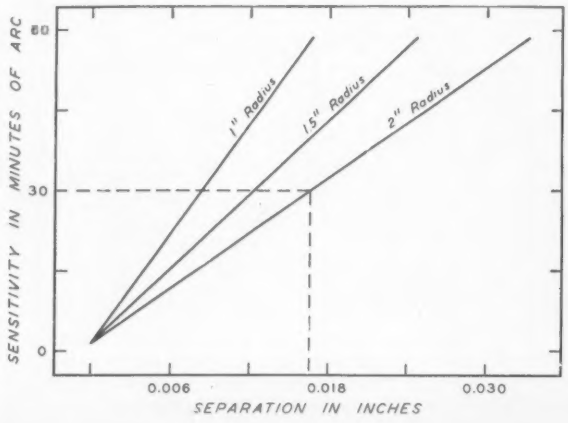
The parts of the mercury level are pictured here, and detailed drawings can be had from the writer upon request. Mercury will not amalgamate with the linen-base bakelite used for the casing, which was easily machined. The main body of the unit, with the mercury chamber, is at the left in the picture. Barely visible is a recessed hole for the ground connection, allowing it to make a good deep contact in the liquid.

The cover of the leveler rests on one edge of the base shown here; it contains the four contact points for indicating tilt. At the upper right is the cap containing red windows for night-viewing of the bulbs. The eyelet extending from this part is a ground connection to the base cover, while the main power cord leads out of the picture. At the right, in front of the cap, is the spring-metal holder for the bulbs.

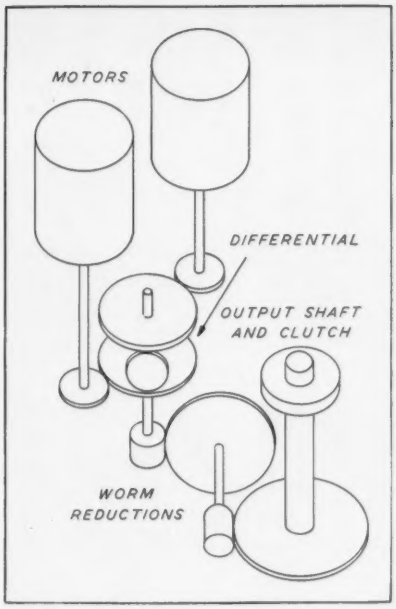
Sensitivity of the level to tilt of the mounting is determined by the radius of the ring of contact points and by their linear distance above the surface of the liquid. In the chart, the diagonal lines indicate the sensitivity for contact points of 1", 1½", and 2" radii from the level's center. The dashed lines show that for a level sensitivity of half a degree, a chamber of 2" effective radius should have a mercury contact separation of 0.017".

This is the optimum sensitivity, for reducing it below half a degree makes the unit too delicate to adjust for a field device. Even at this value, the vertical support screws should not be too coarse. The actual contact separation can be adjusted to whatever value is desired if a cardboard spacer of the proper thickness is inserted before the chamber is filled with mercury. Avoid spilling the liquid, as its vapor is toxic.

A sketch of our clock drive and guiding control is shown opposite. Many gear combinations can be evolved to achieve the sidereal rate, but a practical choice



The dependence of leveling sensitivity on the separation of the mercury's surface from the contacts is plotted here. It varies with the radius from the center of the chamber to the bulb positions, as indicated by the three diverging lines.



The general layout of the clock-drive parts. No actual gear sizes and ratios are given, as these depend on the operating voltage, found only after the electronic control has been built.

must have ample clearances between centers, and not too much gear torque. Shafts should be as short as possible, with the bearings mounted close to the gears they support.

A friction clutch or release for pointing the telescope manually must be installed between the final drive shaft and the last gear, for the telescope cannot be set against the locking action of the gear train.

A mechanical differential makes push-button guiding possible. Driving the differential, located at the primary end of the gear train, are two motors with outputs of 4.5 and 3 r.p.m. When these are run in the same direction the differential adds their outputs; it subtracts when they turn in opposite directions.

If the differential is a standard unit, its internal ratio of 2 to 1 must be included in the gear-reduction computation. When both motors are turning in the same direction, the differential output is half of 4.5 + 3, or 3.75 r.p.m. When the motors oppose each other the output is half of 4.5 − 3, or 0.75 r.p.m.

Unless the voltage is kept constant, however, the sidereal drive motor will change its speed and fail to track accurately. This is one of the drawbacks of using ignition batteries. To overcome this difficulty, John Stone designed the transistorized voltage control sketched here. It takes the 6-volt battery supply and delivers it to the motor at a reduced but constant 3.9 volts, thus compensating for the gradual decrease in battery output during its life.

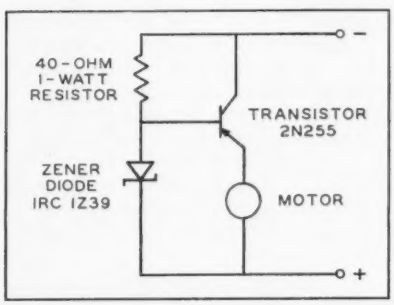
The Zener diode acts as a reference while the supply voltage slowly drops, adjusting the base-bias control voltage to the transistor through the 40-ohm resistor by changing the transistor impedance to a lower value. This causes an increase in current flow to the motor, resulting in a constant output speed.

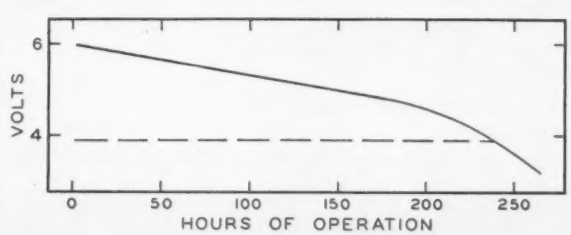
The need for this voltage control is the reason for operating the motor at reduced voltage. However, as the characteristics of production-line low-cost transistors vary greatly, and the tolerances of the Zener diode may cause slight output variations, it is almost impossible to predict the motor's actual speed. Therefore, the circuit should be breadboarded and operated with its motor to determine the actual speed at the operating voltage. This must be carefully determined before the gear train is designed.

Although the motor torque is reduced at the lower voltage, it has proved sufficient to operate our 8-inch instrument. One 6-volt battery powers both motors and the mercury level. The surplus motors we obtained have an internal gear reduction. They draw about 175 milliamperes each, which is a modest drain on the battery. After a year of intermittent service, the original battery is still in use.

The clock drive and associated circuit are mounted on the latitude-adjustment plate. The polar-axis drive shaft extends through the plate, ending in a machined taper section to permit separation of the base from the fork and tube. An index pin is located at the large diameter of the taper to lock the joint during operation.

A slip-ring assembly is recessed within the latitude plate to transfer battery





The electronic control circuit, above, gives a constant motor speed at reduced voltage, compensating for the gradual decline in battery voltage, indicated by the graph at the right.

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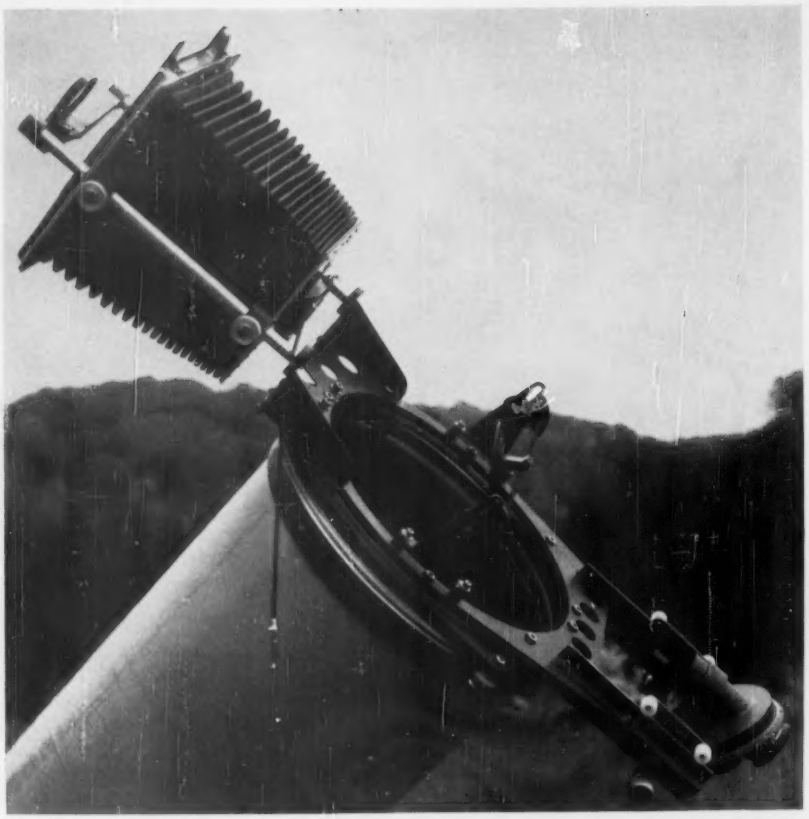

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power to a declination motor drive, which has been completed but not yet installed. It will be placed between the yoke brackets under the declination axis, and will require a counterweight on the opposite side.

At the upper end of the tube, the eyepiece turret and camera have a common base plate. Three nylon V-shaped rollers are mounted 120° apart and secured under the base with short retainer bushings. The rollers ride in the V-slotted ring secured to the end of the tube, and can turn through the full 360°. To direct the image from the primary mirror to either the eyepiece turret or the camera, the diagonal mirror can be turned through 90°, as has been mentioned. In the camera, a standard shutter has been fitted with an achromatic Barlow lens for increasing the image size of the sun or moon. Because of its unshielded position, the camera cannot be used for stellar photography.

The mechanical differential was obtained as a surplus item from Soundtronics Labs, 630 Arch St., Philadelphia, Pa., and the motors from Herbach and Rademan, Inc., 1204 Arch St., in the same city. The self-aligning Monoball bearings are from Southwest Products Co., 1705 S. Mountain Ave., Monrovia, Calif.

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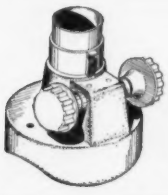

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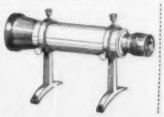

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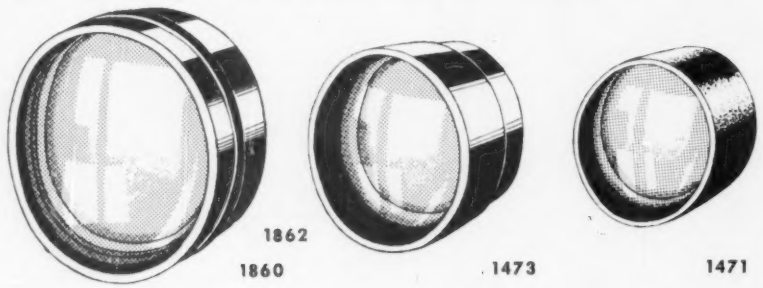

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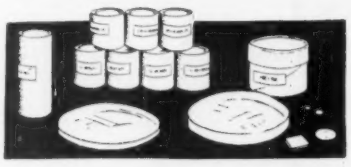
$1093	(3¼")	(28")	28.00
$1139	(3¼")	(30")	28.00
S–955	(3¼")	(34½")	28.00
S–957	(3¼")	(40")	$30.00
$1155	(4")	(34½")	60.00
$1460	(4¼")	(36")	60.00
$1159*	(4⅜")	(42")	60.00
$1225	(4⅜")	(42")	67.50
$1474*	(5-1/16")	(24¾")	75.00
$1475	(5-1/16")	(24¾")	85.00

*Not coated.

Astronomical Mirror Grinding Kits



● FREE OFFER ●

Now you can save many tedious hours of grinding time. Tool and blank of No. S2053 and No. S2054 have a generated f/8 curve. Take advantage of this extra special offer at no additional cost.

NOTE: For those who desire to grind a curve to their own specifications, the standard blanks are also offered as manufactured, without the generated curve.

EACH KIT CONTAINS: Mirror blank, plate-glass tool, eyepiece lenses, first-surface diagonal mirror, assorted abrasives, tempered pitch, and inspection magnifying lens.

Cat. No.	Mirror Diam.	Thickness	ppd.
$2053	4¼" (f/8 curve)	¾"	$ 7.50
$2093	4¼" (flat)	¾"	7.50
$2054	6" (f/8 curve)	1"	11.95
$2094	6" (flat)	1"	11.95
$2055	8" (flat)	1⅜"	19.50
$2056	10" (flat)	1¾"	30.75
$2057	12" (flat)	2⅛"	54.75

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FOR TELESCOPES UP TO 4"

Constructed of cast aluminum and finished in black. The tripod is war-surplus, one of the sturdiest of its size ever built. Made of prime oak with bronze fittings, 3 adjustable locking legs with steel shods. Extended 50", closed 36". Shipping weight is 13 lbs.

Cat. No. $2128 EQUATORIAL MOUNT .... $17.50 ppd.
Cat. No. $2131 TRIPOD ..... 15.00 ppd.

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Cat. No. $2083 Combination EQUATORIAL MOUNT and TRIPOD ..... f.o.b. Lynbrook, N. Y., $27.50

Reflector Telescope Kits

Excellent quality mirrors, polished, aluminized, silicon-monoxide coated. Each kit contains mirror, diagonal, and lenses for eyepiece. No metal parts. Mounting instructions included.

Cat. No.	Diam.	F.L.	ppd.
$2284	3-3/16"	42"	$ 9.95
$2285	4¼"	45"	14.75
$2286	6"	60"	26.25

Astronomical Mirrors

These mirrors are of the highest quality. Aluminized with silicon-monoxide protective coating. You will be more than pleased with their performance.

Cat. No.	Diam.	F.L.	ppd.
$1429	3-3/16"	42"	$ 8.70
$1506	4¼"	45"	13.50
$1507	6"	60"	25.00
$2188	6" parabolic	48"	49.50

Mirror Mounts

Cast aluminum, holds all of our mirrors with metal clips. Completely adjustable, assembled.

Cat. No. $1634 3-3/16" Mount for 4½" Tubing $4.00 ppd.
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Cat. No. $1632 6" Mount for 7" Tubing 6.50 ppd.

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Cat. No.	Size	Field at 1,000 yards	Type	Price, ppd.
S1149	6 x 15 IF	360 ft.	Opera	$12.75
S1436	6 x 30 CF	395	"Zeiss"	18.75
S1435	6 x 30 IF	395	"Zeiss"	16.75
S1438	7 x 35 CF	341	"Zeiss"	20.75
S1437	7 x 35 IF	341	"Zeiss"	17.95
S1771	7 x 35 CF	341	American	23.50
S1439	7 x 35 CF	578	American*	35.00
S2191	7 x 50 CF	530	American**	42.50
S1106	7 x 50 CF	372	"Zeiss"	24.95
S-961	7 x 50 IF	372	"Zeiss"	22.50
S1503	7 x 50 CF	372	American	32.50
S1443	8 x 30 CF	393	"Zeiss"	21.00
S1229	8 x 30 IF	393	"Zeiss"	18.25
S1108	10 x 50 IF	275	"Zeiss"	26.75
S1442	20 x 50 CF	183	"Zeiss"	33.75

*Wide-angle 11° **Wide-angle

All prices above plus 10% Federal tax.

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Brand new, coated optics, complete with pigskin case and neck straps.

Cat. No. S1576.....6 x 30.....**$10.00 ppd.**
Cat. No. S1577.....8 x 30.....**11.25 ppd.**
Cat. No. S1578.....7 x 35.....**12.50 ppd.**
Cat. No. S1303.....7 x 50.....**14.75 ppd.**
Cat. No. S1579.....16 x 50.....**17.50 ppd.**
Cat. No. S1580.....20 x 50.....**20.00 ppd.**

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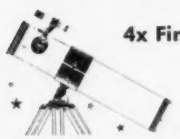
Cat. No. S2303 ..... **$39.75 ppd.**

4¼" Reflector Telescope

35x — 175x
4x Finder — Wood Tripod



From the mysterious craters of the moon to the fabulous rings of Saturn, this high-quality telescope will give you many pleasurable hours of crystal-clear astronomical viewing. Contains an f/6 parabolic mirror which gives a 50-per-cent brighter image than the ordinary f/10. Two coated eyepieces, 35x and 175x; rack-and-pinion focusing; sun filter; and 4x focusing finder. Its short tube, 27¾" long, and collapsible wood tripod (33" closed, 60" open), make for portability, stability, and compactness. Finished in white enamel with black trim. Imported. Shipping weight about 20 lbs.

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Cat. No. S2273 ..... **f.o.b. Lynbrook, N. Y., $59.50**

8-Power Elbow Telescope

This telescope has a brilliant-image 48° apparent field; actually 325 feet at 1,000 yards. Can be adjusted for focusing 15 feet to infinity. 2" achromatic objective, focusing eyepiece 28-mm. f.l., Amici erecting system. Turret-mounted filters: clear, red, amber, and neutral. Lamp housing to illuminate reticle for night use. Truly the biggest bargain you were ever offered. Original Gov't. cost $200.

8 x 50

Cat. No. S1686 Not Coated ..... **$13.50 ppd.**
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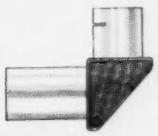
Cat. No. S2301 ..... **$2.50 ppd.**

Star Diagonals



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RIGHT-ANGLE PRISM STAR DIAGONAL

Contains a high-quality aluminized right-angle prism, wide field. Practical for astronomical use.

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MIRROR STAR DIAGONAL

Diagonal houses an excellent first-surface mirror, flat to within ¼ wave. Important accessory for refractor telescopes.

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Will accommodate finder above. Made of cast aluminum with black crackle finish. Each ring has three locking wing screws for adjusting. Base has two holes for mounting screws, fits any diameter tubing. Easy to mount. Inside diameter of ring mount 1-15/16".

Cat. No. S1963 ..... **Per Pair** ..... **$3.95 ppd.**

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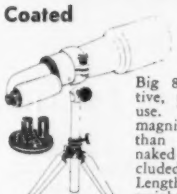
Coated **80-mm. Objective**



Big 80-mm.-diam. (3⅛") objective, for spotting or astronomical use. Will show stars of the 11th magnitude — 100 times fainter than the faintest visible to the naked eye. Table-top tripod included, extended 18", closed 13¼". Length of scope 16¼". Combined weight of scope and tripod is 5¼ lbs. All coated optics.

FIVE EYEPIECES

Power	Field at 1,000 yards	Exit pupil diam.	Relative brightness
15x	122 ft.	5.4 mm.	29
20	122	4.0	16
30	61	2.7	7
40	49	2.0	4
60	32	1.3	1

Cat. No. S2052 ..... **$59.50 ppd.**

60-mm.-diam. Scope. Same as above but with smaller objective. Equipped with same five eyepieces — 15x, 20x, 30x, 40x, 60x. Coated. With tripod.

Cat. No. S1721 ..... **$42.95 ppd.**

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Cat. No.	F.L.	Type	ppd.
S2192	6 mm. (¼")	Orthoscopic	$13.25
S1851	6 mm. (¼")	Ramsden	4.75
S1853	12.5 mm. (½")	Ramsden	4.50
S1207	12.5 mm. (½")	Symmetrical	6.00
S1251	16 mm. (⅝")	Erfle (wide-angle)	12.50
S1257	16 mm. (⅝")	Orthoscopic	12.50
S1209	18 mm. (¾")	Symmetrical	6.00
S1211	22 mm. (27/32")	Kellner	6.00
S1835	27 mm. (1-1/16")	Kellner	4.50
S1355	32 mm. (1¼")	Plossl	12.50
S1253	35 mm. (1⅜")	Symmetrical	8.00
S1255	55 mm. (2-3/16")	Kellner	6.00
S1485	56 mm. (2¼")	Symmetrical	6.00

COATED LENSES 75 cents extra.

"Giant" Wide-Angle Eyepiece

Coated Lenses

Erfle eyepiece best for low-power performance. Superior six-element design. 65° field, 1½" E.F.L., clear aperture 2⅛", focusing mount and diopter scale. Combine this eyepiece with our 5" objective No. S1475 for a tremendous light-gathering Rich-Field Telescope.

Cat. No. S1405 (illustrated) ..... **$12.50 ppd.**
Cat. No. S1858 Same as above without diopter scale ..... **$ 9.95 ppd.**

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With S1405

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ADAPTER PLATE AND TUBE. Aluminum tapered tube and adapter plate, black anodized and finished in black crackle. Slides into our 5" O.D. Aluminum Tubing No. S1511. These parts are used with the eyepieces above to make a Rich-Field Telescope. Details in our catalogue.

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Brand-new eyepiece with 68° field; coated. E.F.L. 1¼". Focusing mount, 3 perfect achromats, 1-13/16" aperture.

Cat. No. S1020 ..... **$13.50 ppd.**
Cat. No. S1593 1¼"-diam. ADAPTER for eyepiece above ..... **3.95 ppd.**

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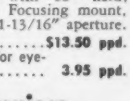
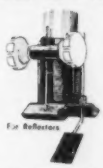


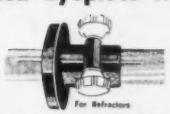
This mounted eyepiece has two magnesium-fluoride-coated achromatic lenses 29 mm. in diameter. Excellent definition. E.F.L. 1¼". Cell fits 1¼" tubing.

Cat. No. S1911 Coated ..... **$5.90 ppd.**
Cat. No. S1991 Not Coated ..... **5.25 ppd.**

Rack-&-Pinion Eyepiece Mounts



For Reflectors



For Refractors

Here is a wonderful opportunity for you to own a most mechanically perfect Rack-&-Pinion Focusing Eyepiece Mount with variable tension and adjustment. Will accommodate a standard 1¼" eyepiece, positive or negative. The body casting is made of lightweight aluminum with black-crackle paint finish, focusing tube of chrome-plated brass. Focusing tube for refractors has a travel of 4", for reflectors 2", and will fit all size tubing.

REFRACTOR TYPE

Cat. No. S1494 for 2⅛" I.D. Tubing ..... **$12.95 ppd.**
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REFLECTOR TYPE

Cat. No. S1976 (less diagonal holder) ..... **$8.50 ppd.**
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CELESTIAL CALENDAR

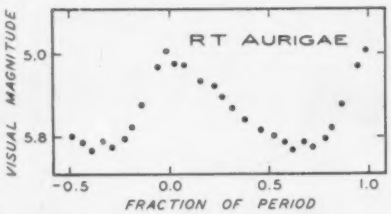
Universal time (UT) is used unless otherwise noted.

RT AURIGAE

IF you are one of the many amateurs who use binoculars to study the heavens, it is worth while to make the acquaintance of the star RT Aurigae, located at $6^h\ 25^m.4$, $+30°\ 32'$ (1950 coordinates), not far from Epsilon Geminorum. Its brightness oscillates between the magnitude limits 5.0 and 5.9 in a period of 3 days 17.5 hours. Anyone who identifies this star and spends a few moments comparing it with neighboring constant stars on several consecutive nights can easily recognize the variation in its light.

The accompanying light curve was compiled from 358 visual estimates with binoculars by B. V. Kukarkin. It represents a typical Cepheid variable, and may be compared with the one of Delta Cephei itself, on page 710 of SKY AND TELESCOPE for October, 1959. For both stars, the increase of brightness requires only about a third of the time for a complete cycle of light changes.

RT Aurigae was first recognized as a variable by an English amateur, T. H. Astbury, in March, 1905. He was engaged in a systematic search for novae, during which he gained such a familiarity with the stars in the Gemini-Auriga region that the changes in the object then called 48 Aurigae caught his attention. Other members of the British Astronomical Association soon confirmed his find, which was given the designation RT Aurigae. Astbury is also remembered as the discoverer of the Algol-type variable TV Cassiopeiae, close to Beta Cassiopeiae and a good object for work with a 2-inch refractor.



This visual light curve for the bright Cepheid variable star RT Aurigae was derived by the Soviet astronomer B. V. Kukarkin from his estimates of brightness during the years 1925 to 1932. Each point represents the average of 19 or 20 observations. About a dozen Cepheids visible from the United States are bright enough for systematic binocular work. From "Publications" of the Sternberg Institute.

COMET ENCKE

Observers with small telescopes may be able to view Comet Encke during most of January in Aquarius, near the Water Jar in the western evening sky. The following predictions are from S. G. Makover's ephemeris in the 1961 *Handbook* of the British Astronomical Association. Listed here for 0h Universal time on each fifth day are the 1950 right ascension and declination:

January 1, $22^h\ 16^m.7$, $+3°\ 06'$; 6, $22^h\ 14^m.4$, $+2°\ 17'$; 11, $22^h\ 10^m.4$, $+1°\ 10'$; 16, $22^h\ 03^m.4$, $-0°\ 31'$; 21, $21^h\ 51^m.3$, $-3°\ 08'$.

Comet Encke will be about magnitude 9.5 on January 6th and 7.6 on the 16th, according to Mr. Makover. At the time of perihelion passage, February 5th, the comet will be moving rapidly southward, but too near the sun to be seen. During February and March the rapidly fading object will be poorly placed for observation, except from the Southern Hemisphere.

This famous comet was first seen in 1786, but its periodicity was not recognized until 1819 by J. F. Encke. Its period of 3.3 years is still the shortest known. The first photograph made during the current return appeared on page 289 of the November, 1960, issue.

JANUARY METEORS

In northern Bootes is located the radiant point of this month's short Quadrantid meteor shower, named after an old constellation. Unfortunately, the gibbous moon will interfere with observations of shower maximum, which occurs on the morning of January 3rd. Under more favorable conditions, a single observer at maximum might see some 33 Quadrantids in an hour. This shower, like the Geminids and Delta Aquarids, is unusual in that it has never been identified with a comet.

WILLIAM H. GLENN

MOON PHASES AND DISTANCES

Full moon	January	1, 23:06
Last quarter	January	10, 3:03
New moon	January	16, 21:30
First quarter	January	23, 16:14
Full moon	January	31, 18:47
Last quarter	February	8, 16:50

January	Distance	Diameter
Apogee 3, 13^h	252,500 mi.	29′ 24″
Perigee 16, 23^h	221,600 mi.	33′ 30″
Apogee 30, 13^h	252,500 mi.	29′ 24″
February		
Perigee 14, 11^h	222,600 mi.	33′ 22″

MINIMA OF ALGOL

The predictions given on page 385 of last month require a correction of about −5 minutes to be consistent with the ephemeris below.

January 3, 20:14; 6, 17:04; 9, 13:53; 12, 10:42; 15, 7:32; 18, 4:21; 21, 1:10; 23, 22:00; 26, 18:49; 29, 15:39.

February 1, 12:28; 4, 9:18; 7, 6:07; 10, 2:56.

These minima predictions for Algol are based on a recent timing by D. Engelkemeir, and an assumed period of 2.8674 days. The times given are geocentric; they can be compared directly with observed times of least brightness.

VARIABLE STAR MAXIMA

The predicted dates of maximum listed below have been derived recently by the American Association of Variable Star Observers. In some cases they differ from last month's published predictions for early January maxima, which were prepared a year ago.

January 1, S Sculptoris, 001032, 6.8; 8, T Aquarii, 204405, 7.7; 10, S Pegasi, 231508, 8.0; 11, R Ophiuchi, 170215, 7.9; 17, R Normae, 152849, 7.2; 18, RS Librae, 151822, 7.5; 20, R Cygni, 193449, 7.5; 22, S Carinae, 100661, 5.7; 27, U Octantis, 131283, 7.9; 30, R Canum Venaticorum, 134440a, 7.7; 30, R Phoenicis, 235150, 8.0.

February 1, R Leonis, 094211, 5.8; 1, V Bootis, 142539, 7.9; 9, V Coronae Borealis, 154639, 7.5.

These predictions of variable star maxima are by the AAVSO. Stars are listed only if brighter than magnitude 8.0 at an average maximum. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for their maxima. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted visual magnitude.

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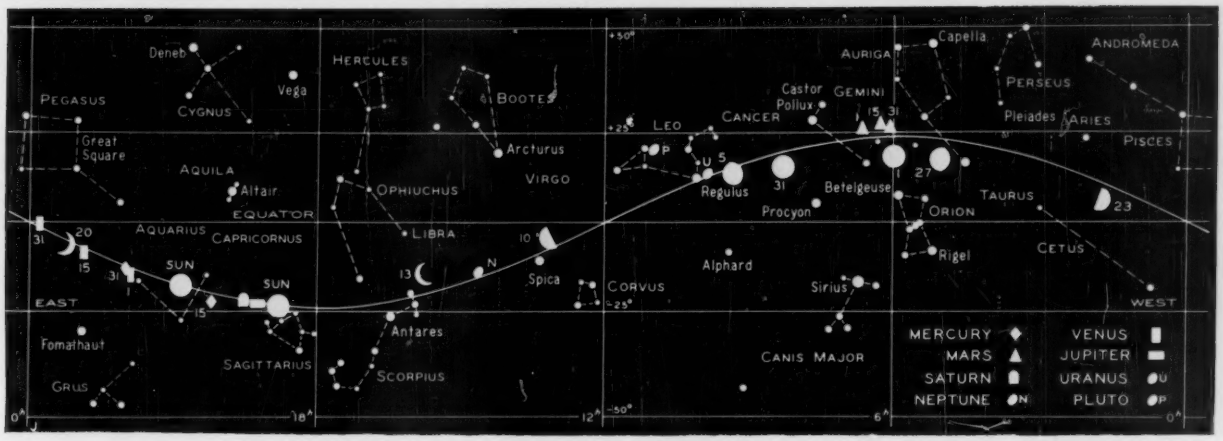


THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other dates shown. All positions are for 0^h Universal time on the respective dates.

Mercury, at superior conjunction with the sun on January 5th, is not visible until the last week of the month, when it may be found low in the western sky after the sun sets. It will appear reddish, and its magnitude of −0.9 will aid the observer who searches for it near Delta Capricorni.

Venus sets more than 3½ hours after the sun all month, and is a brilliant object of magnitude −3.9 in Aquarius. Telescopically, on January 15th the planet has a gibbous disk 21″ in diameter and is 58-per-cent illuminated. Watch for a fine spectacle on the evening of January 19-20, as the crescent moon approaches conjunction with the planet at 5^h Universal time on the 20th. Seen then from the center of the earth, Venus is 0°.6 north of the moon; an occultation will be visible from the South Pacific and Australasia. The greatest eastern elongation of Venus will be reached on the 29th, when it is to be 47° from the sun.

Mars, a conspicuous reddish object of magnitude −1.0 in western Gemini, remains visible most of the night. It crosses the meridian at about 10:30 p.m., local time, in midmonth. Although well placed high in the sky for northern observers, Mars is receding from the earth, and its telescopic disk shrinks from 15″.3 in apparent diameter on January 1st to 12″.6 on the 31st. The moon will pass south of Mars twice in January, on the 1st and 28th.

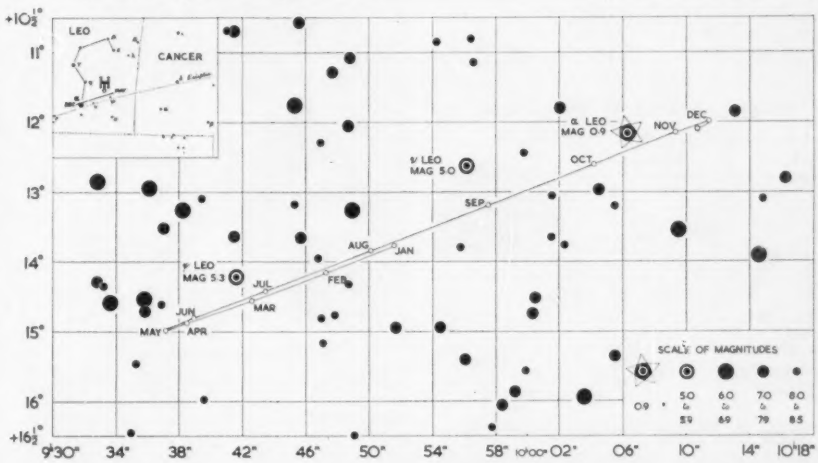
Jupiter reaches conjunction with the sun on January 5th, and remains too close to it to be seen with the unaided eye this month.

Saturn is lost in the solar glare, conjunction occurring on the 11th.

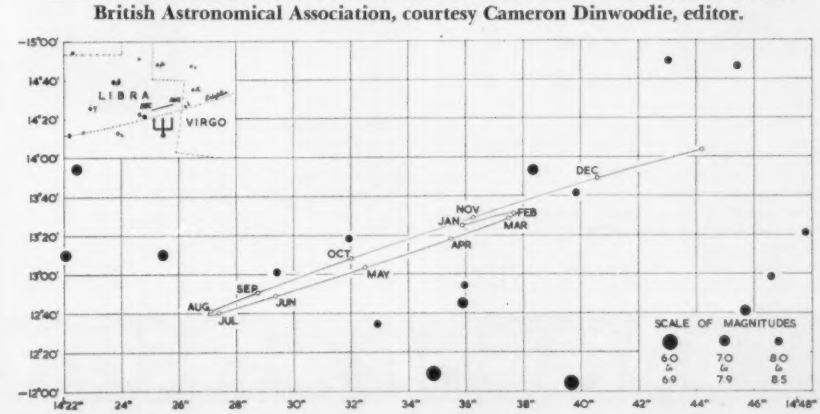
Uranus crosses the meridian about 2¼ hours after local midnight on the 15th, a 6th-magnitude object at right ascension 9^h 49^m.3, declination +13° 59′ (1950 co-ordinates) in Leo, northwest of Regulus. Telescopically, the planet's greenish disk has a 3″.9 diameter.

Neptune on the 15th is of the 8th magnitude, situated in Libra at right ascension 14^h 36^m.4, declination −13° 27′ (1950 co-ordinates). It may be seen with small telescopes in the southeastern sky before dawn, high powers showing a tiny disk, only 2″.4 in diameter.

WILLIAM H. GLENN



The path of Uranus among the stars to magnitude 8.5 in Leo is shown above; that for Neptune among such stars in Libra, below. In each case the field is inverted, with south at the top. (The insets have north upward.) The scales of the two charts are not the same. From the 1961 "Handbook" of the British Astronomical Association, courtesy Cameron Dinwoodie, editor.



UNIVERSAL TIME (UT)

TIMES used in Celestial Calendar are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown. For example, 6:15 UT on the 15th of the month corresponds to 1:15 a.m. EST on the 15th, and to 10:15 p.m. PST on the 14th.

3-inch Astronomical Reflector

60 to 180 Power

An Unusual Buy!

Assembled — ready to use! See Saturn's rings, the planet Mars, huge craters on the moon, star clusters, moons of Jupiter, double stars, nebulae, and galaxies! Equatorial-type mounting with locks on both axes. Aluminized and over-coated 3"-diameter f/10 primary mirror, ventilated cell. Telescope comes equipped with a 60x eyepiece and a mounted Barlow lens, giving you 60 to 180 power. A finder telescope, always so essential, included. Sturdy, hardwood, portable tripod.

FREE with Scope: Valuable **STAR CHART** plus 272-page **"HANDBOOK OF THE HEAVENS"** plus the book **"HOW TO USE YOUR TELESCOPE."**

Stock #85,050-Y.....$29.95 ppd.

4¼" ASTRONOMICAL TELESCOPE

UP TO 255 POWER

New Vibration-Free Metal Pedestal Mount

With this scope you can see everything described above, but with greater power. Also, it will split closer double stars. Mirror has twice the light-gathering power. Rack-and-pinion focusing, real equatorial mounting — only one motion needed to follow the stars! Aluminum tube. 6-power finder telescope. 2 standard-size eyepieces and mounted Barlow lens give you powers of 40x, 90x, 120x, and 255x. Low-cost accessory eyepiece available for higher powers. **FREE** with Scope: Valuable **STAR CHART** plus 272-page **"HANDBOOK OF THE HEAVENS"** plus the book **"HOW TO USE YOUR TELESCOPE."** Shipping wt. 25 lbs.

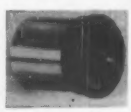
Stock #85,105-Y.....$79.50 f.o.b. Barrington, N. J.

Same telescope as described above but equipped with Electric Clock Drive.

Stock #85,107-Y.....$109.00 f.o.b. Barrington, N. J.

NOW! A FULL SELECTION OF ORTHOSCOPIC EYEPIECES

Wide, flat field — better correction under high magnification — excellent eye relief.



The orthoscopic eyepiece is one of the most important and best corrected eyepieces for astronomical work. These are of a four-element design, with coated lenses, and are standard 1¼" outer diameter, precision made of chrome-plated brass and aluminum.

Stock #30,364-Y..... 4 mm.....$14.50 ppd.
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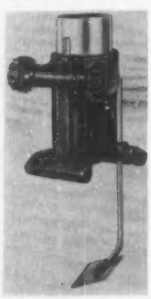
Stock #30,406-Y..... 18 mm..... 14.50 ppd.
Stock #30,407-Y..... 25 mm..... 14.50 ppd.

Rack-&-Pinion Eyepiece Mounts



Real rack-and-pinion focusing with variable tension adjustment; tube accommodates standard 1¼" eyepieces and accessory equipment; lightweight aluminum body casting (not cast iron); focusing tube and rack of chrome-plated brass; body finished in black wrinkle paint, No. 50,077-Y is for reflecting telescopes, has focus travel of over 2", and is made to fit any diameter or type tubing by attaching through small holes in the base. Nos. 50,103-Y and 50,108-Y are for refractors and have focus travel of over 4". Will fit our 2⅞" I.D. and our 3⅞" I.D. aluminum tubes, respectively.

For Reflectors

Stock #50,077-Y..(less diagonal holder)....**$8.50 ppd.**
Stock #60,049-Y..(diagonal holder only).... **1.00 ppd.**

For Refractors

Stock #50,103-Y..(for 2⅞" I.D. tubing)....**12.95 ppd.**
Stock #50,108-Y..(for 3⅞" I.D. tubing)....**13.95 ppd.**

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For Boys — Girls — Adults!

Excellent "Science Fair" Materials

Science Treasure Chest — Extra-powerful magnets, polarizing filters, compass, one-way-mirror film, prism, diffraction grating, and lots of other items for hundreds of thrilling experiments, plus a Ten-Lens Kit for making telescopes, microscopes, etc. Full instructions included.

Stock #70,342-Y.....$5.00 ppd.

Science Treasure Chest De Luxe — Everything in chest above, plus exciting items for more advanced experiments including crystal-growing kit, electric motor, molecular models set, first-surface mirrors, and lots more.

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BINOCULAR-TO-CAMERA HOLDER

For Exciting Telephoto Shots

Will fit any camera

Bring distant objects 7 times nearer with a 35-mm. camera, 7 x 50 binocular, and our BINOCULAR-TO-CAMERA HOLDER. Ideal for photographing constellations, star clusters, the moon, as well as cloud formations, wildlife, vistas. Camera and binocular attach easily. Use any binocular or monocular — any camera, still or movie. Take color or black-and-white. Attractive gray crinkle and bright chrome finish, 10" long. Full directions for making telephoto pictures included.

Stock #70,223-Y.....$11.50 ppd.

Take Pictures Through Your Telescope with the EDMUND CAMERA HOLDER for TELESCOPES

Bracket attaches permanently to your reflecting or refracting telescope. Removable rod with adjustable bracket holds your camera over scope's eyepiece and you're ready to take exciting pictures of the moon. You can also take terrestrial telephoto shots of distant objects. Opens up new fields of picture taking!

SUN PROJECTION SCREEN INCLUDED

White metal screen is easily attached to holder and placed behind eyepiece. Point scope at sun, move screen to focus . . . and you can see sunspots!

All for the low, low price of $9.95

Includes brackets, 28¾" rod, projection screen, screws, and directions. Aluminum; brackets black crinkle painted.

Stock #70,162-Y.....$9.95 ppd.

PRISM STAR DIAGONAL

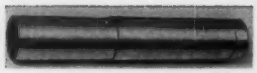
For comfortable viewing of stars near the zenith or high overhead with refracting telescopes using standard-size (1¼" O.D.) eyepieces, or you can make an adapter for substandard refractors. Contains an excellent high-quality aluminized right-angle prism. The tubes are satin chrome-plated brass. Body is black wrinkle cast aluminum. Optical path length of the system is about 3½".

Stock #70,077-Y.....$12.00 ppd.

AMICI-PRISM STAR DIAGONAL

Same as above except contains Amici roof prism instead of usual right-angle prism. Thus your image is correct as to top-bottom, making it excellent for terrestrial viewing.

Stock #50,247-Y.....$12.00 ppd.



NOW! LENS ERECTOR FOR TERRESTRIAL VIEWING WITH YOUR REFLECTOR

This Edmund development adds real convenience to viewing objects on the earth. Just put the lens erector in your eyepiece holder, insert eyepiece, and focus normally. You see everything right side up and correct as to left and right. Made of polished chrome-finish brass telescoping tubing that will fit any standard 1¼" eyepiece holder. Tubing is 9½" long and slides 3" into eyepiece holder. Erecting system consists of two coated achromats.

Stock #50,276-Y.....$9.95 ppd.

STAR TIME CALCULATOR

This handy slide rule automatically makes the conversion from star or sidereal time to standard time. Saves the amateur astronomer the time and trouble of calculations. Size: 10⅓" x 3⅝", plastic coated cardboard.

Stock #40,399-Y.....$1.50 ppd.

"MAKE YOUR OWN" 4¼" MIRROR KIT

The same fine mirror as used in our telescopes; polished and aluminized, with lenses for eyepieces, and diagonal. No metal parts.

Stock #50,074-Y.....$16.25 ppd.

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CIRCULAR DIFFRACTION-GRATING JEWELRY

A Dazzling Rainbow of Color!

Shimmering rainbows of gemlike color in jewelry of exquisite beauty — made with CIRCULAR DIFFRACTION-GRATING REPLICAS. Just as a prism breaks up light into its full range of individual colors, so does the diffraction grating. Promises to become a rage in current fashion. 1" diam.

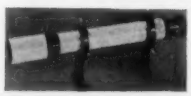
Stock #30,349-Y..Earrings .....$2.75 ppd.
Stock #30,350-Y..Cuff Links .....$2.75 ppd.
Stock #30,372-Y..Pendant .....$2.75 ppd.
Stock #30,390-Y..Tie Clasp .....$2.75 ppd.

WAR-SURPLUS TELESCOPE EYEPIECE

Mounted Kellner eyepiece, type 3. Two achromats, focal length 28 mm., eye relief 22 mm. An extension added, O.D. 1¼", standard for most types of telescopes. Gov't. cost $26.50.

Stock #5223-Y.....$7.95 ppd.

6X FINDER TELESCOPE



Has crosshairs for exact locating. You focus by sliding objective mount in and out. Base fits any diameter tube — an important advantage. Has 2 holders each with 3 centering screws for aligning with main telescope. 20-mm.-diameter objective. Weighs less than ½ pound.

Stock #50,121-Y.....$8.00 ppd.

STANDARD 1¼" EYEPIECE HOLDER

Here is an economical plastic slide-focus eyepiece holder for 1¼" O.D. eyepieces. Unit includes 3"-long chrome-plated tube into which your eyepiece fits for focusing. Diagonal holder in illustration is extra and is not included.

Stock #60,067-Y.....$2.50 ppd.

Stock #60,049-Y
Diagonal holder.....**$1.00 ppd.**

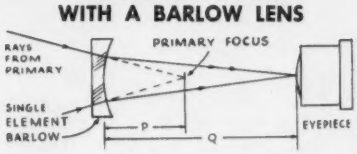
EDMUND SCIENTIFIC CO.

THE ORIGINAL GOODWIN RESOLVING POWER BARLOW

For many years, this achromatic-coated Barlow lens has been the pride and joy of serious astronomers. Due to the death of the designer, Mr. Frank Goodwin, it has not been available for the past two years. NOW, we can offer these lenses, in exact accordance with the original specifications. Remember, this Barlow is achromatic, coated, mounted in a blackened tube, and as optically perfect as only precision craftsmen can make it. Complete with instructions, in a 4"-long adapter tube for standard 1¼" eyepieces.

Stock #60,122-Y.....**$23.50 ppd.**

DOUBLE AND TRIPLE YOUR TELESCOPE'S POWER WITH A BARLOW LENS



WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q.

Beautiful chrome mount. We now have our Barlow lens mounted in chrome-plated brass tubing, with special spacer rings that enable you easily to vary the power by sliding split rings out one end and placing them in other end. Comes to you ready to use. Just slide our mounted lens into your 1¼" I.D. tubing, then slide your 1¼" O.D. eyepieces into our chrome-plated tubing. Barlow lens is nonachromatic.

Stock #30,200-Y...Mounted Barlow lens....**$8.00 ppd.**

UNMOUNTED 3X BARLOW LENS

These lenses are made for telescopes that have smaller-diameter eyepieces than the standard 1¼" size. Mount one between the eyepiece and objective, and triple your power. Instructions included. Single-element lens, focal length —1-5/16", unmounted.

Stock #30,185-Y....0.932" diam.....**$3.50 ppd.**
Stock #30,328-Y....0.912" diam.....**$2.50 ppd.**

3X ADJUSTABLE-DIAMETER BARLOW LENS

For telescopes with eyepieces smaller than the standard 1¼" outer-diameter size. Prongs on mount can be opened or closed to fit tubes from 13/16" to 1" inner diameter. Directions for using included.

Stock #30,339-Y.....**$5.00 ppd.**

MORE POWER FROM YOUR JAPANESE TELESCOPE

Mounted Barlow for Japanese Telescopes

By inserting this single-element lens in the eyepiece end of your Japanese telescope, and putting your regular eyepiece in the end of the Barlow tube, you can increase your telescope's power up to three times. Thus, instead of 60x, you will get 120x or 180x. Barlow is mounted in two pieces of telescoping brass tubing each 4" long, satin chrome plated on the outside. Inner diameter of large tube and outer diameter of small tube are 0.965", the standard size for most Japanese telescopes. Measure yours before ordering. 0.965" is approximately 31/32" or 24.5 mm.

Stock #30,370-Y.....**$6.00 ppd.**

SPECIAL! VARIABLE 10- TO 20-POWER U. S. ARMY OBSERVATION TELESCOPE

This is the most versatile and complete government - surplus telescope unit we have ever offered you. USES: spotting scope, surveying, balloon and satellite tracking, all general observation. *THE TELESCOPE:* Elbow-type, 10 to 20 power continuously variable. Field of view 6° 9′ to 3° 5′. 2¼" objective lens. Focusing eyepiece. *THE MOUNTING:* This is really something! Has completely enclosed 8"-diam. circle scale reading directly to 1/10 mil or approx. 20 seconds. (6400 mils equal 360°.) Clutch release allows rapid rotation. Rotates 90° horizontal to vertical with direct reading to 1 mil. Has crossed levels, precision adjustment, and many other exciting features. *THE TRIPOD:* Made of solid oak with brass fittings. Has cast brass head with four leveling screws. Legs adjustable from 30" to 52" excluding mount height. Extremely sturdy and rigidly cross braced. Instruments used but in good condition. Shipping wt. approx. 100 lbs.

Stock #85,117-Y.....**$89.50** f.o.b. Chicago

CLOCK-DRIVEN EQUATORIAL MOUNT ON PEDESTAL BASE IDEAL FOR YOUR 6" OR 8" REFLECTOR

Accurate electric clock drive and heavy-duty mounting. Operates on household current. Follows stars smoothly. Pedestal is 24" high. Polar-axis shaft diameter 1".

Stock #85,111-Y.....**$74.50** f.o.b. Barrington, N. J.

Same mount and clock drive on 32" hardwood tripod.

Stock #85,081-Y.....**$69.00** f.o.b. Barrington, N. J.

Same mount on metal pedestal, no clock drive.

Stock #85,108-Y.....**$45.00** f.o.b. Barrington, N. J.

Same mount on tripod, no clock drive.

Stock #85,023-Y.....**$39.50** f.o.b. Barrington, N. J.

FREE! "Astronomy and You"

New booklet in comic-book style tells about astronomy from historic times to the present, also covers telescopes and telescope making. Free, on request, with your order. Also available in quantity to astronomy groups for star parties, meetings, to museums, planetariums or school groups. Refer to this *Sky and Telescope* ad in writing us.

Mounted Ramsden Eyepieces

Standard 1¼" Diameter

Our economy model, standard-size (1¼" O.D.) eyepiece. We mounted two excellent quality plano-convex lenses in black anodized aluminum barrels instead of chrome-plated brass to save you money. The clear image you get with these will surprise you. Directions for using short focal length eyepieces are included with both the ¼" and ½" models.

Stock #30,204-Y.....¼" focal length.....**$4.75 ppd.**
Stock #30,203-Y.....½" focal length.....**$4.50 ppd.**

NEW! SCIENCE FAIR PROJECT KITS

Edmund kits are carefully planned to give any boy or girl the fun and excitement of discovering science facts. Such carefully planned projects can lead the student to awards or scholarships. Adults too will find them an excellent introduction to the various fields of science.

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COLOR THROUGH POLARIZATION — Show the beautiful color effects produced by passing polarized light through transparent objects.
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OPTICAL ILLUSION KIT — Diagrams, lenses, mirrors, etc., for producing many amazing optical illusions.
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GIANT ERFLE EYEPIECE 1½" F.L.

War-Surplus Bargain — Gov't. Cost Approx. $100

Large telescopes should have one of these for low-power viewing. Apparent field of view 65°. Also use with the 24"-focal-length Aerial Camera lens to make a 16-power wide-field telescope or a 27-power scope with one of the 40"-focal-length Aerial Camera lenses. Low-reflection-coated, 5-element lens system. Field lens of Eastman Kodak's rare-earth glass for better aberration correction. Has diopter scale. Smooth focusing ⅜" movement. Outside diameter of attaching threads, 3" — 32 threads per inch. Clear aperture of eye lens 2", field lens 1-25/32". Weight 3½ lbs.

Stock #50,091-Y.....**$9.95 ppd.**

ADAPT GIANT ERFLE TO STANDARD TELESCOPE EYEPIECE SIZE

This adapter lets you use our Giant Erfle with any telescope having a standard 1¼"-diam. eyepiece holder.

Stock #50,358-Y.....**$3.95 ppd.**

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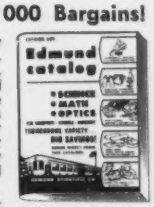
144 Pages! Over 1000 Bargains!



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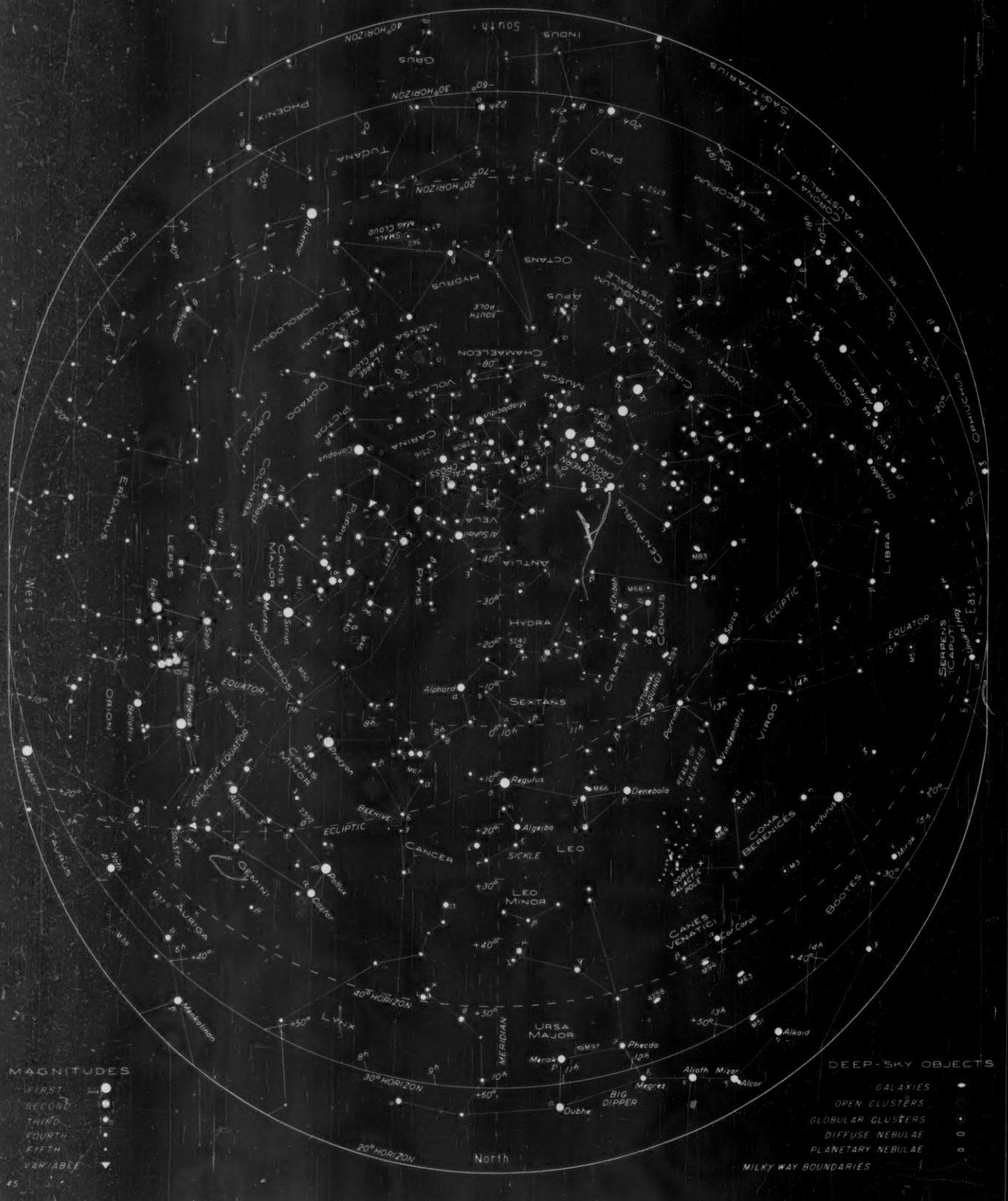

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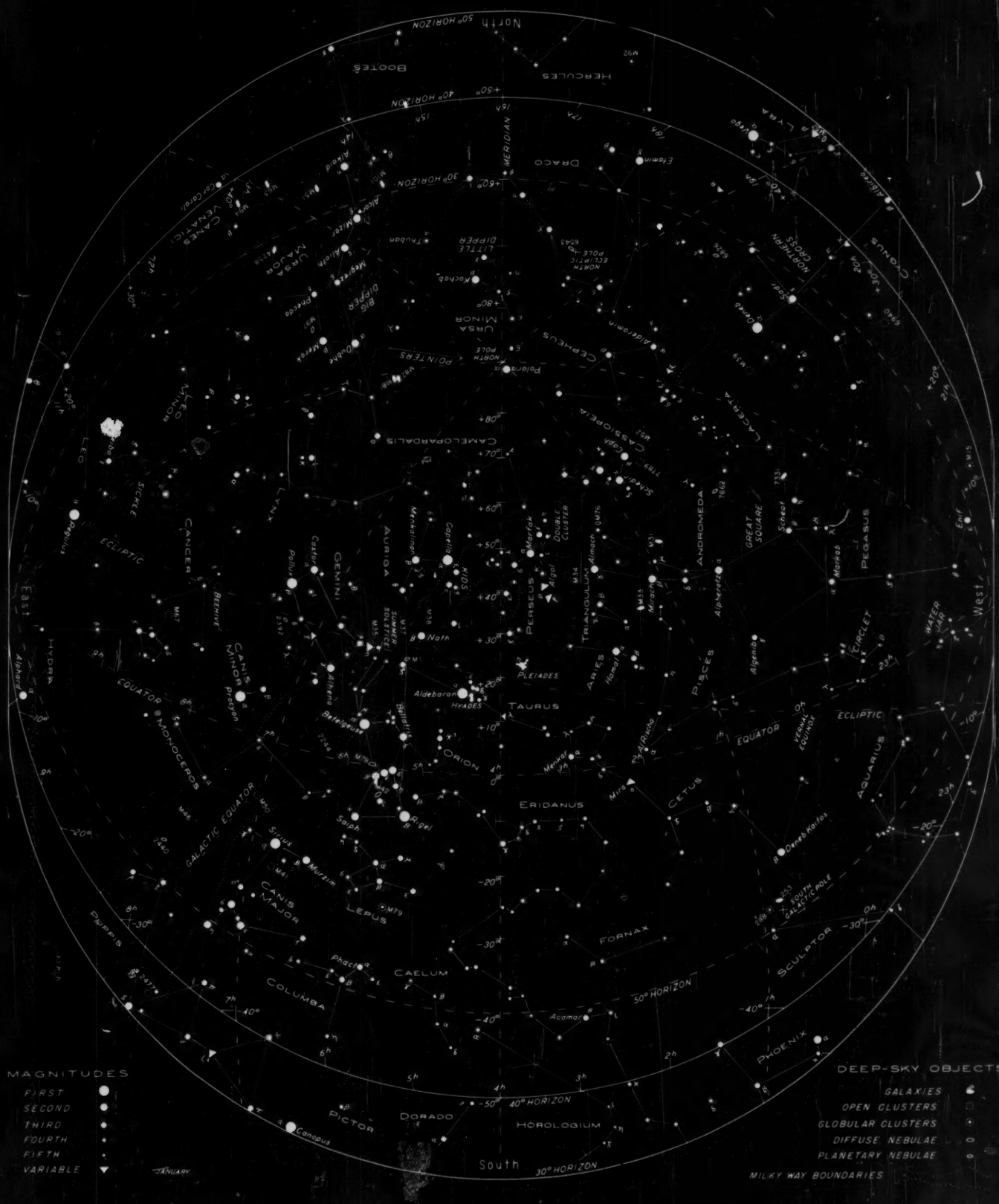
SOUTHERN STARS

The sky as seen from latitudes 20° to 40° south, at 11 p.m. and 10 p.m., local time, on the 8th and 23rd of March, respectively; also, at 9 p.m. and 8 p.m. on April 7th and 22nd. For other dates, add or subtract ½ hour per week.

Well up the northern sky and roughly parallel to the Milky Way is the straggling constellation of Hydra the Water Monster. Its triangular head of five stars lies near Cancer, where Praesepe, the Beehive cluster, is easily recognized with the unaided eye on a clear, dark night.



STARS FOR JANUARY

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 6th and 21st of January, respectively; also at 7 p.m. and 6 p.m. on February 5th and 20th. For other dates, add or subtract ½ hour per week.

A winter evening is an excellent time to become acquainted with star colors. In Orion, contrast the red hue of Betelgeuse with the blue-white of Rigel. Aldebaran is orange, Sirius white. Searching the Milky Way with binoculars will reveal other red stars.

St. Louis Planetarium Package

ENGINEERED BY ASTRO-DOME

for one of our most astronomically minded communities

The first planetarium in the United States to be built at public expense (financed by a municipal bond issue) is now being constructed in St. Louis, Missouri. The project was described in "Sky and Telescope" five years ago (October, 1955, page 502). It will feature a major planetarium projector, a 60-foot perforated interior dome with a theater chamber seating up to 400 persons, and a uniquely modern building designed by Gyo Obata, with spacious exhibit halls, an observing roof, and space for a moderate-sized telescope for public observing.

Astro-Dome has been awarded the contract for the following package:

1. The projector itself — a full-sized Goto instrument, Model L-1, equal or superior in every respect to other major projectors, incorporating numerous features never before perfected. It will reproduce every aspect of the starry sky, all planetary motions for all points of time, and have auxiliary equipment for all special events, such as eclipses, northern lights, and planetary conjunctions.
2. The 60-foot perforated aluminum projection screen, which will stand self-supported in the center of the main exhibit hall. With a newly perfected method of joining the seams of the dome segments, the interior will present a beautifully smooth, unmarred appearance.
3. A massive 70-foot outer steel dome covered with plaster and encasing the projection screen. In this construction, Astro-Dome's long experience in dome structures will prove invaluable. A spiral ramp will then be added to the exterior of the steel dome, leading to the observing roof.
4. A dual-stereo audio system, being designed so that all kinds of audible phenomena can be produced, adding to the realism of the planetarium presentation.

As this project moves ahead, Astro-Dome will work in close co-ordination with the general contractors, the Gamble Construction Co.; the architects, Helmuth, Obata, and Kassabaum; the St. Louis Planetarium Commission; and members of the St. Louis Astronomical Society, who have for many years been prime movers in this project.

If you or your community are contemplating a planetarium installation, large or small, Astro-Dome stands ready to serve you. This work is made easier by our distributorship for the world-famous planetariums of the Goto Optical Manufacturing Co. in Japan.

Serving the Astro-Sciences

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MANUFACTURERS OF ASTRONOMICAL OBSERVATORY DOMES
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CUSTOM DYNASCOPES—PRICE AND DELIVERY SCHEDULE

CONVENIENT TIME PAYMENT PLANS AVAILABLE ON ALL MODELS

SIX-INCH STANDARD	SIX-INCH DELUXE	EIGHT-INCH STANDARD	EIGHT-INCH DELUXE	10-INCH DELUXE	12.5-INCH DELUXE	16-INCH OBSERVATORY MODEL
$265 Complete	$475 Complete	$385 Complete	$595 Complete	$895 Complete	$1,265 Complete	$4,200 up
Shipping Weight 80 lbs.	Shipping Weight 150 lbs.	Shipping Weight 145 lbs.	Shipping Weight 185 lbs.	Shipping Weight 245 lbs.	Shipping Weight 300 lbs.	Equipped To Your Specifications
21 Day Delivery		21 Day Delivery		30 Day Delivery	30 Day Delivery	

Standard Six and Eight Inch Models Do Not Include Electric Clock Drive, Setting Circles, Slow Motion Control Or Pier
All Telescopes Are Shipped F.O.B. Hartford, Connecticut • No Additional Charge For Packing and Crating

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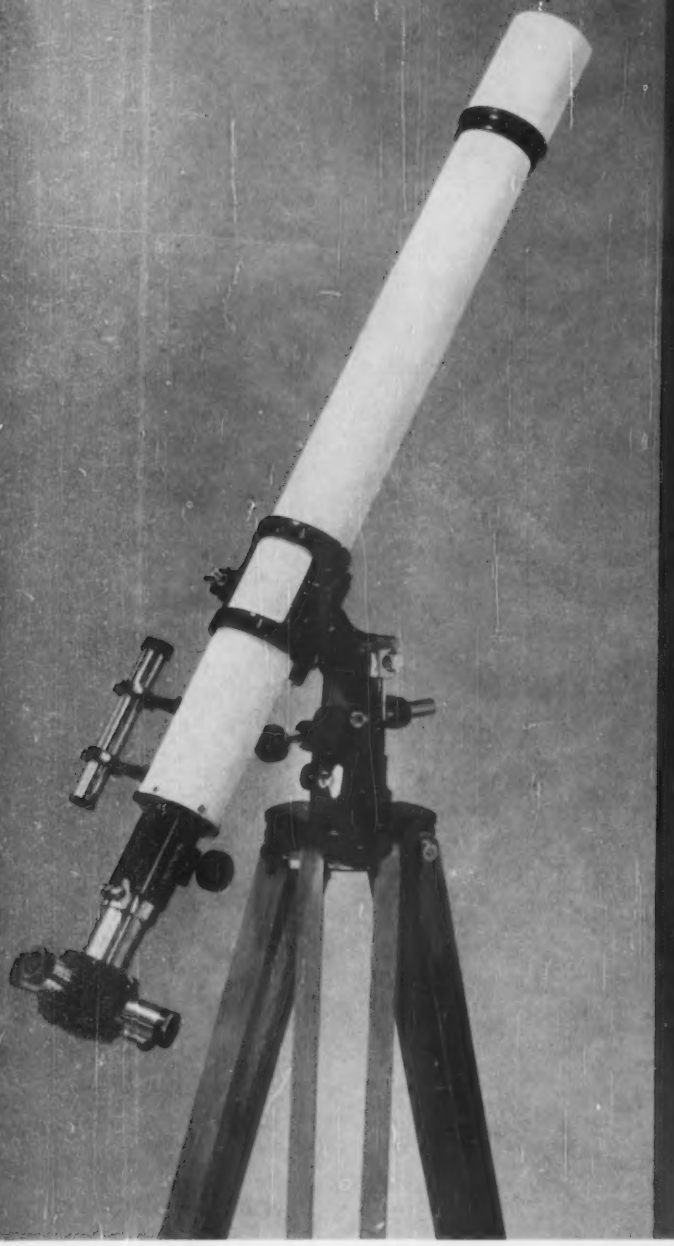
AN OPEN AND SHUT CASE OF UNITRON SUPERIORITY...

All this telescope.....



in one compact, lightweight traveling case!

The Unitron 2.4" altazimuth refractor shown here is now packaged in a new, specially designed, lighter, more compact carrying case that's much easier to carry, much thriftier on trunk space when you're traveling by car. (Weight: just 25 lbs.)

But portability is only the second most important feature of this fine instrument.

The first most important feature of the Unitron 2.4" altazimuth refractor continues to be its downright value and upright optical excellence.

Excellence and value — these are enduring qualities, common to every Unitron sold. The best possible proof: Unitron is the largest selling refractor in the world.

What you'll find inside the new Unitron carrying case: Model 114 — complete with altazimuth mounting and slow-motion controls for both altitude and azimuth, tripod, 5x-16mm viewfinder, standard rack and pinion mechanism, 4 eyepieces, UNIHEX or star diagonal and erecting prism system, sunglass, dewcap, dustcap, instructions. **$125**

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SEE PAGES 50 AND 51 FOR MORE ABOUT UNITRON.